FEBRUARY, 1950

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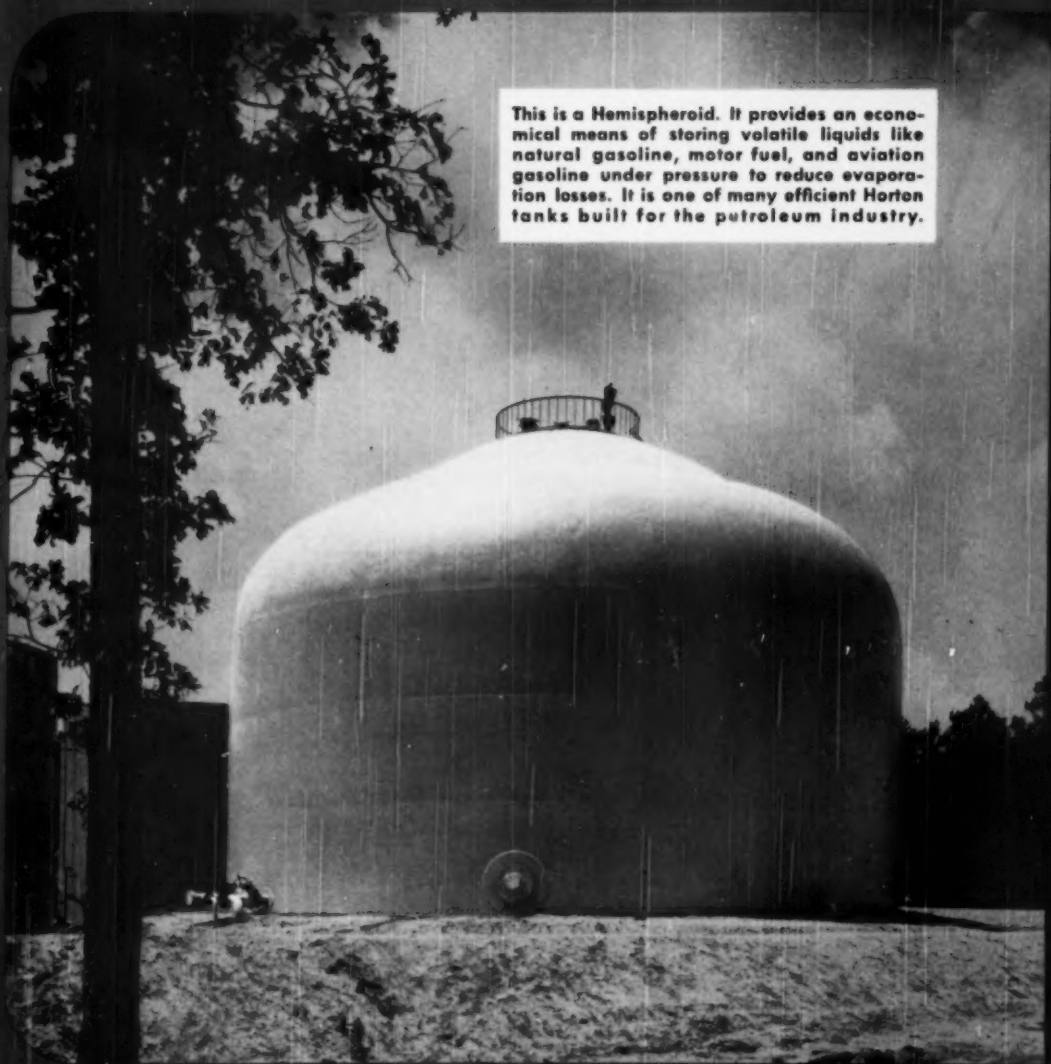

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VOLUME 29, NO. 2 — FEBRUARY, 1950

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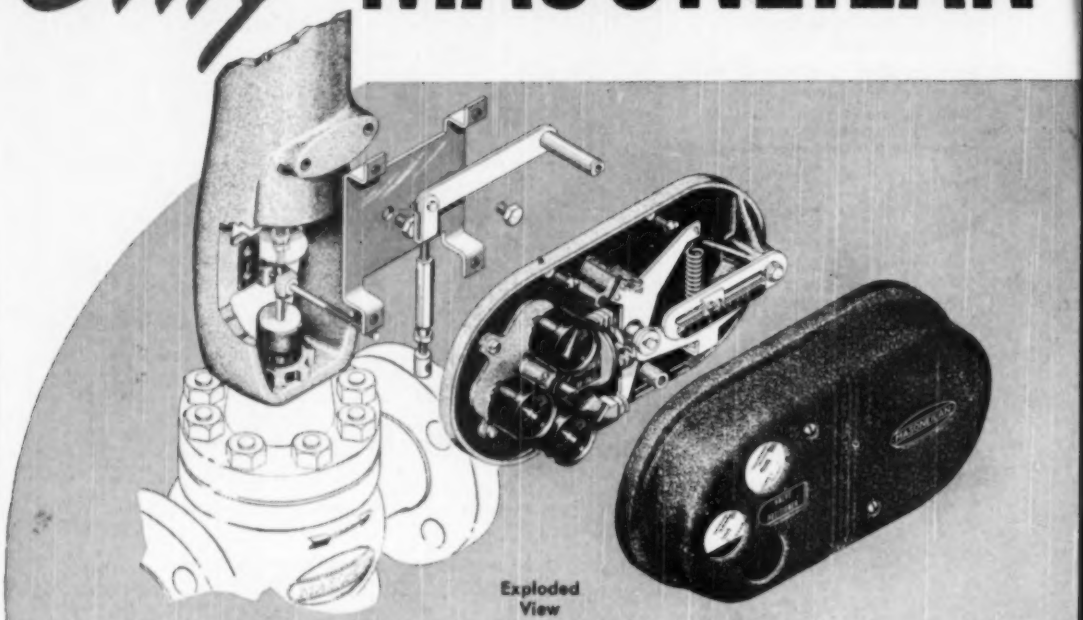

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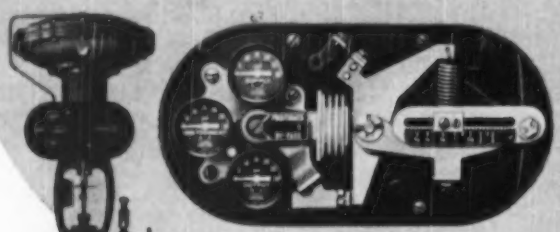
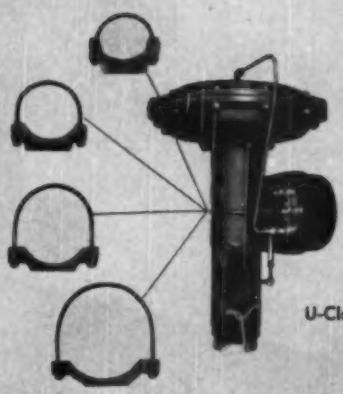


Interior View of Case



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Physical data and prices on all sizes and types of Armstrong steam traps.

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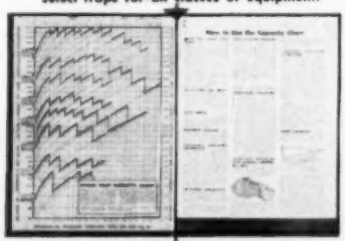

Actual hot condensate capacity chart for every Armstrong trap, recommended safety factors and specific recommendations for many types of equipment.

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Anyone is welcome to a copy of this useful guide to good trapping practice. Send for yours today.

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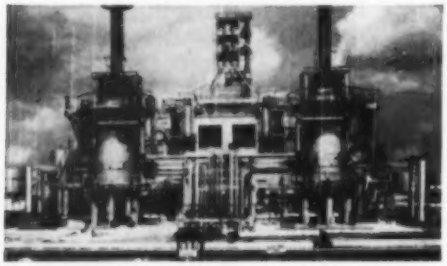
ARMSTRONG STEAM TRAPS

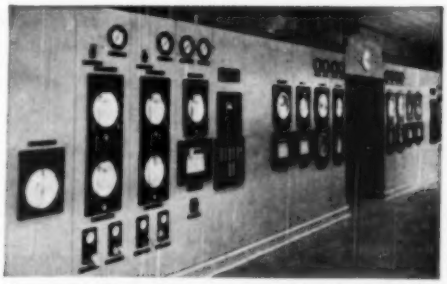
Cit-Con widens Lube-Oil horizons

Cit-Con's "twin" vacuum distillation units shown here can each handle 12,500 barrels a day of reduced crude. Design provides over-capacity to produce a higher proportion of neutral oils to bright stock when required.



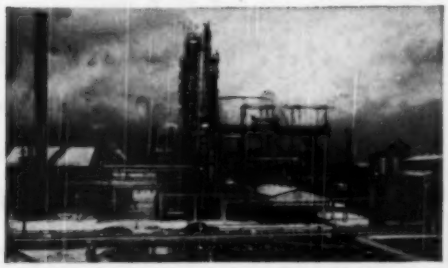
Lummus vertical heaters distinguish Cit-Con's two identical clay contact plants. One handles light distillates; and the other, heavy distillates and bright stocks.

The new Cit-Con lubricating oil plant at Lake Charles, La., is an outstanding example of Lummus' design and construction. From the beginning, the project kept pace with pre-planned schedules. Currently, operations and products are meeting the most modern standards.

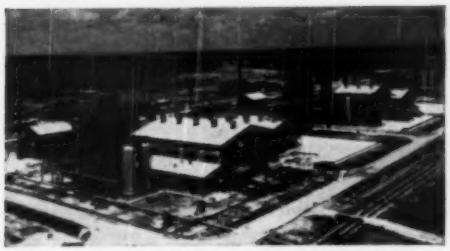


Vacuum units have a common, streamlined control room. This view shows instrument board and instruments for both of the distillation units.

This air view shows the L-shaped layout of the processing units. From right to center foreground can be seen, in order: vacuum distillation units, solvent refining units, and the boiler house in the corner. Continuing to the left around the L are the two MEK dewaxing units, the clay contact plant, and the wax finishing unit.



The furfural extraction unit is of exceptionally high capacity with two stages of furfural recovery on the raffinate system and four stages on the extract system. The solvent circulation rate is 30,000 barrels daily.



This general view shows in close-up, from left to right, MEK dewaxing units No. 1 and 2, and the clay contact plant. The No. 1 MEK plant for light distillates has recrystallization facilities which may be equipped later for incremental dilution. The other plant for heavy intermediate distillate and bright stock is presently equipped with repulping facilities to reduce oil content of the amorphous type wax.

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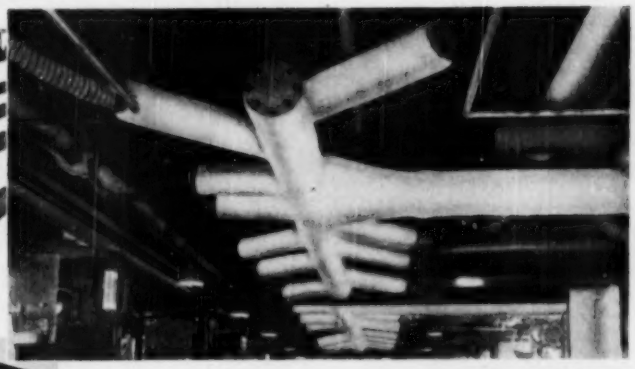
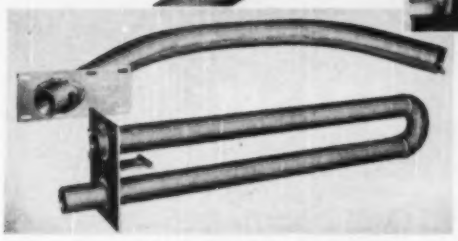
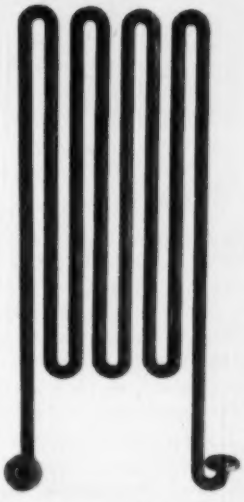




Typical PSC welded tubing assemblies for the process industries.
Upper left, tubing of 25 Chrome-20 Nickel for a chemical plant.
Upper right, manifold for exhausting hot gases.
Left, furnace tubes.
Right, for synthetic rubber plant.



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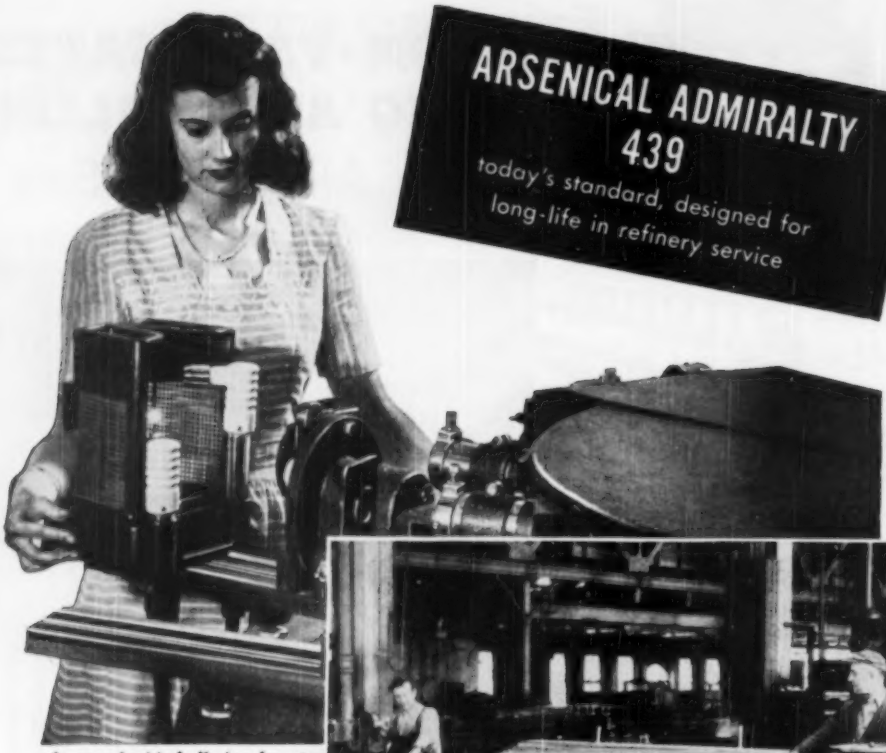

Amount of critical alloying elements is checked in the laboratory with the help of this grating-type spectograph.

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NEWS

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FROM MIDGETS TO GIANTS range the size of pressure vessels and welded structures manufactured in A. O. Smith Vessel plants. To the left is part of an order for 2 ft. dia. x 80 ft. long storage tanks. Below are four huge lined coke drums, 16 ft. dia. by 91 ft., being manufactured simultaneously.

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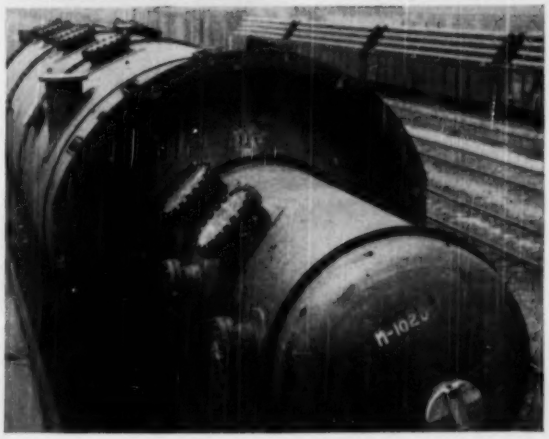
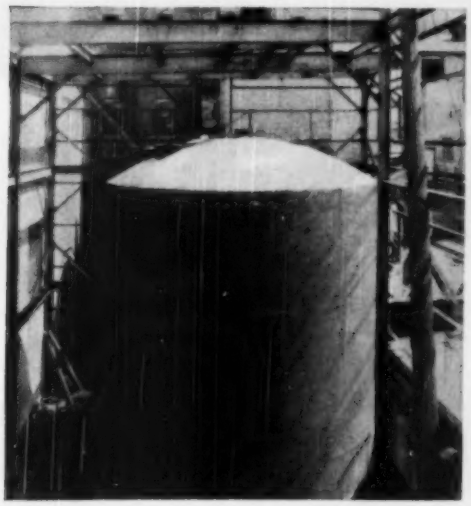
A. O. SMITH IS A LEADER in manufacturing plain carbon steel and corrosion-resistant pressure vessels. This A. O. Smith Vacuum Column, partially lined with type 405 stainless steel, combines extensive knowledge of both types of manufacture.





A. O. Smith Corporation, Dept. PR-250
Milwaukee 1, Wisconsin

Send the latest A. O. Smith Vessel Bulletins:

- ☐ V-46: Alloy, Alloy-lined, Clad, and Glass-lined Vessels
- ☐ V-44: Field Assembly of Pressure Vessels
- ☐ V-52: Multi-Layer Manufacture and Assembly

To:_____

Firm_____

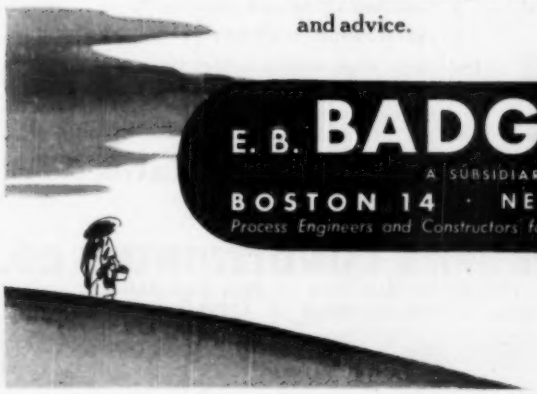
Street_____ City_____ State_____

Cosmopolitan

Badger services have no geographical limitations. Badger-built refineries and processing plants are operating successfully all over the globe, from the deserts of Saudi-Arabia to the jungles of Burma, from Uruguay to Italy. The performance of these plants demonstrates Badger's "know-how" in applying broad experience to petroleum and chemical engineering work anywhere in the world, including adaptations to meet varying climatic conditions.

Wherever your project may be located, Badger will complete the design and procure all necessary materials either in this country or abroad. For the benefit of clients in the sterling area, engineering and purchasing services are provided by our London organization. This allows free choice in the most expedient allocation of currencies.

Facilities can be erected either by our own top complement of construction personnel or by local subcontractors operating under our general supervision and advice.



E. B. BADGER & SONS CO. · Est. 1841

A SUBSIDIARY OF STONE & WEBSTER, INC.

BOSTON 14 · NEW YORK · PARIS · LONDON

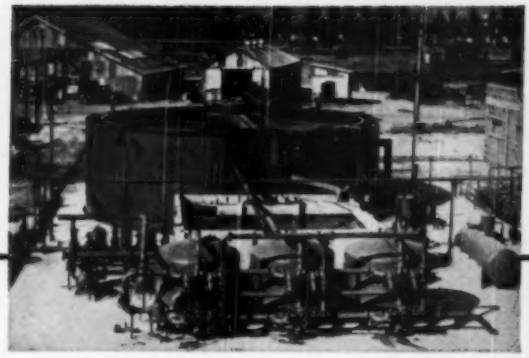
Process Engineers and Constructors for the Petroleum, Chemical and Petro-Chemical Industries

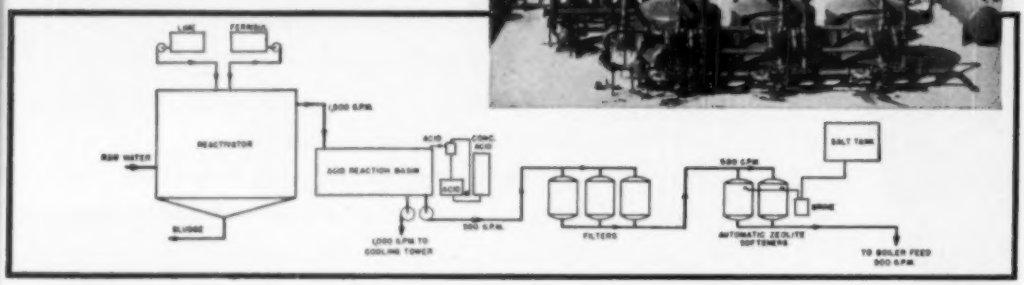
How Tide Water Oil Uses

GRAVER

FOR

COMPLETE WATER TREATMENT





At Tide Water Oil Company's Avon, California, refinery a turbid hard water supply is completely conditioned for boiler feed and cooling water services by Graver equipment consisting of Reactivator, Acid Feeding System, Anthrafilt Filters and Automatic Zeolite Softeners as shown in the flow chart above.

The raw surface water, with an inlet turbidity of 250 ppm, is first treated with lime and ferric sulfate in the Graver Reactivator. Here, partial reduction of hardness takes place while the turbidity is reduced to 3-5 ppm.

The Graver Acid Feeding System continuously and automatically proportions acid to the Reactivator effluent to reduce the alkalinity and to correct the pH to the desired value. Part of the water is thus conditioned for the cooling water system. The remainder of the water is filtered in the Graver Anthrafilt Filter and softened to zero hardness in the Graver Zeolite Softener for use as boiler feedwater.

The completeness of GRAVER service on this job is further accentuated by the facts that GRAVER:

1. **recommended to the Engineers the most effective type of equipment for their requirements.**
2. **built all the major component parts of each Water Treating Unit in its own shops.**
3. **furnished all needed accessories.**
4. **supervised the installation of the equipment.**

This *single responsibility* assures satisfactory operation of every GRAVER installation.

For best results in solving *your* water treatment problem, get the benefit of GRAVER'S 40 years of specialized experience, proven designs, and unequalled facilities. Be sure to ask for GRAVER recommendations.

GRAVER WATER CONDITIONING CO.

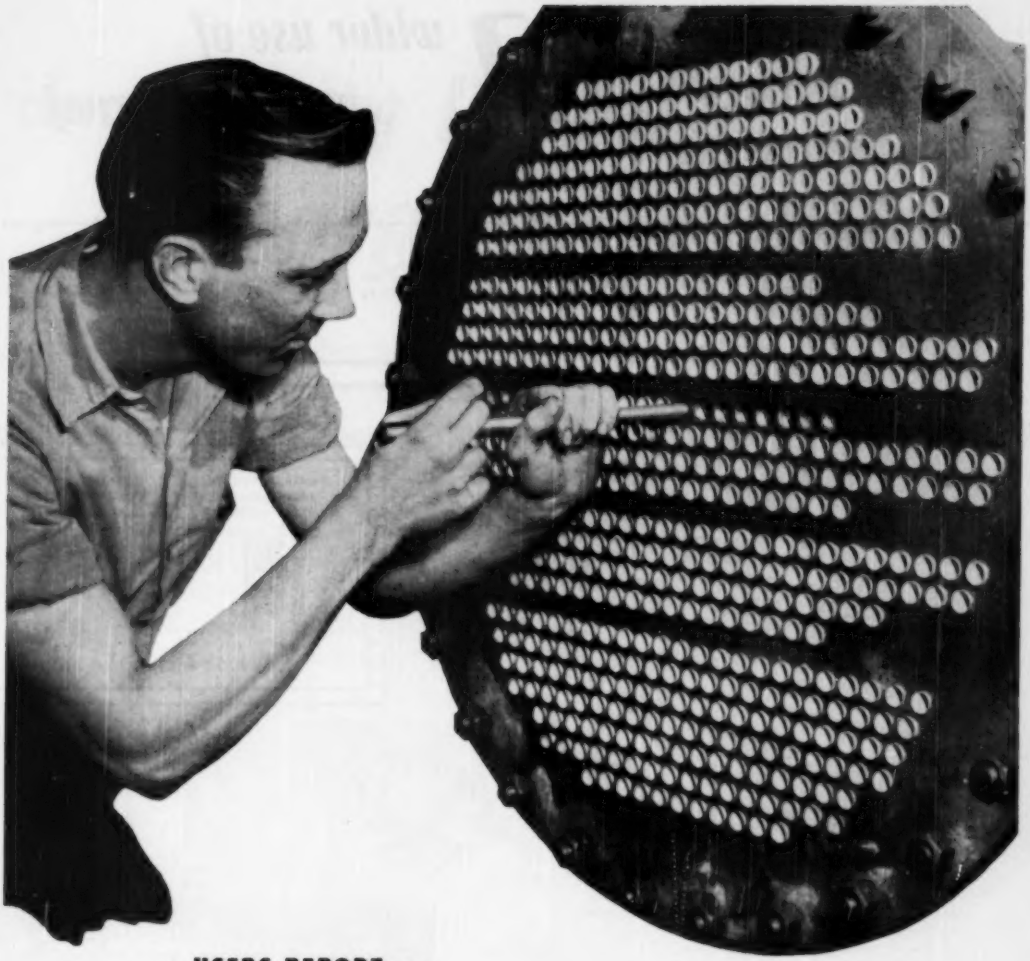
216 West 14th Street, New York 11, New York, U.S.A.

CHICAGO • PHILADELPHIA • CLEVELAND

GW-415

GRAVER

A DIVISION OF GRAVER TANK & MFG. CO. INC. EAST CHICAGO, IND.



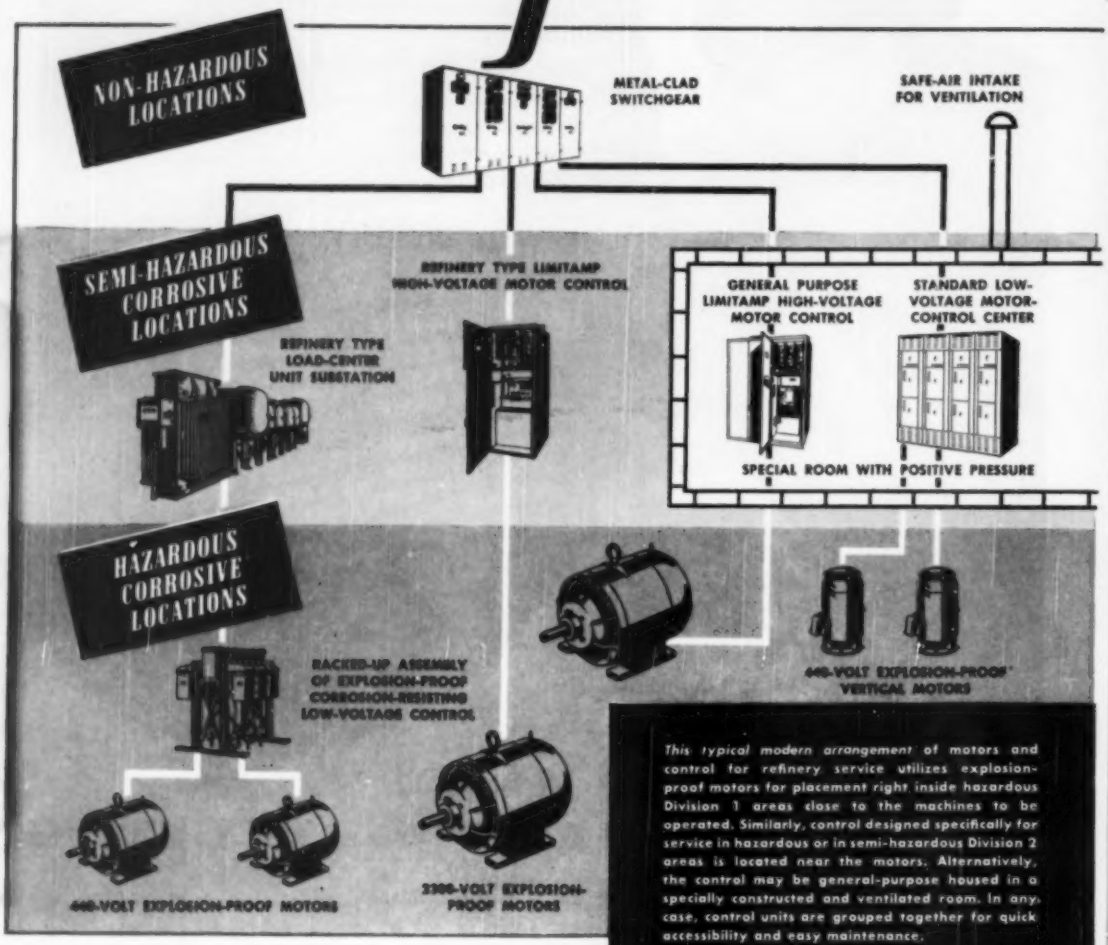
USERS REPORT...

"UP TO 30% FASTER RETUBING WITH ELECTRUNITE"... due to consistently uniform ductility, straightness, diameter and concentricity—qualities which characterize all carbon and stainless steel pressure tubes made by the ELECTRUNITE Welding Processes. Why don't you try them? Write *today*.

REPUBLIC STEEL CORPORATION
STEEL AND TUBES DIVISION • CLEVELAND 8, OHIO
Export Dept.: Chrysler Building, New York 17, N.Y.

Republic
REPUBLIC STEEL
ELECTRUNITE
BOILER, CONDENSER AND HEAT EXCHANGER TUBES

What's the trend in refinery electrification? } wider use of explosion-proof


NON-HAZARDOUS LOCATIONS
METAL-CLAD SWITCHGEAR
SAFE-AIR INTAKE FOR VENTILATION
SEMI-HAZARDOUS CORROSIVE LOCATIONS
REFINERY TYPE LIMITAMP HIGH-VOLTAGE MOTOR CONTROL
REFINERY TYPE LOAD-CENTER UNIT SUBSTATION
GENERAL PURPOSE LIMITAMP HIGH-VOLTAGE MOTOR CONTROL
STANDARD LOW-VOLTAGE MOTOR-CONTROL CENTER
SPECIAL ROOM WITH POSITIVE PRESSURE
HAZARDOUS CORROSIVE LOCATIONS
BACKED-UP ASSEMBLY OF EXPLOSION-PROOF CORROSION-RESISTING LOW-VOLTAGE CONTROL
440-VOLT EXPLOSION-PROOF VERTICAL MOTORS
440-VOLT EXPLOSION-PROOF MOTORS
2300-VOLT EXPLOSION-PROOF MOTORS

This typical modern arrangement of motors and control for refinery service utilizes explosion-proof motors for placement right inside hazardous Division 1 areas close to the machines to be operated. Similarly, control designed specifically for service in hazardous or in semi-hazardous Division 2 areas is located near the motors. Alternatively, the control may be general-purpose housed in a specially constructed and ventilated room. In any case, control units are grouped together for quick accessibility and easy maintenance.

Here's what you need in motors and control for hazardous areas! }

WHEN YOU COME TO GENERAL ELECTRIC you get far more than the finest in electrical equipment. A General Electric application engineer, familiar with refinery practice, is at your disposal. If desired, he stands ready to take over the job of co-ordinating all the needed components, engineering your power distribution and utilization equipment into one modern, efficient system.

corrosion-resisting **motors and grouped controls**

—to simplify plant layouts, cut special construction costs!

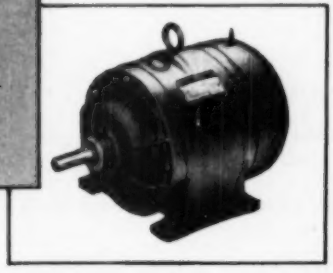
There are more ways than one, of course, to meet hazardous refinery conditions. But because it best combines simplicity, security, and savings, today's trend is toward greater use of explosion-proof, corrosion-resisting motors and group installation of control centers.

Its advantages? Motors and control can be located solely with reference to convenience, accessibility for maintenance, economy of space, and driving machinery. And because it's standard equipment, initial cost is lower.

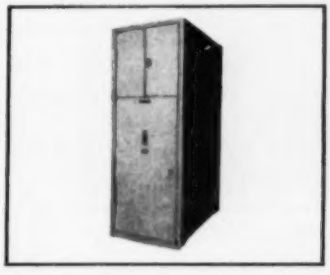
By minimizing explosion hazards, you promote personnel safety and continuity of production. Moreover, you can take full advantage of the cost-saving benefits of the load-center system of power distribution. Full information on motors and control for hazardous areas is contained in Bulletin GEA-4131. We'll gladly send you a copy. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

Have you seen the "More Power to America" full-color sound slidefilm "Modern Industrial Power Distribution"? Ask your G-E representative to arrange a showing for your organization.

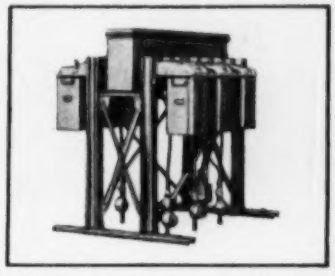
To meet refinery conditions and code requirements for hazardous areas, General Electric builds the most extensive line of explosion-proof motors on the market, in the widest variety of types, sizes, and ratings, and for the greatest number of hazardous conditions. In high- and low-voltage control, too, you have an unusually broad range to select from, made especially for use in hazardous and corrosive atmospheres. Let an experienced G-E engineer help you select the right combination for *your* special needs. Take the first step now—just call him at your nearest G-E office.



G-E Tri-Clad explosion-proof motors for Class I Group D hazardous locations have strong cast-iron frames and end shields. Non-sparking Textolite cooling fans standard on smaller sizes for greatest corrosion resistance.



G-E Limitamp high-voltage motor controls for semi-hazardous Class I Group D Division 2 areas—factory-assembled, space-saving units—give adequate short-circuit protection with high-IC current-limiting fuses.



G-E low-voltage control for hazardous Class I Group D Division 1 areas—in these convenient, racked-up standard assemblies of combination starters and breakers—save installation time, simplify maintenance.

GENERAL ELECTRIC

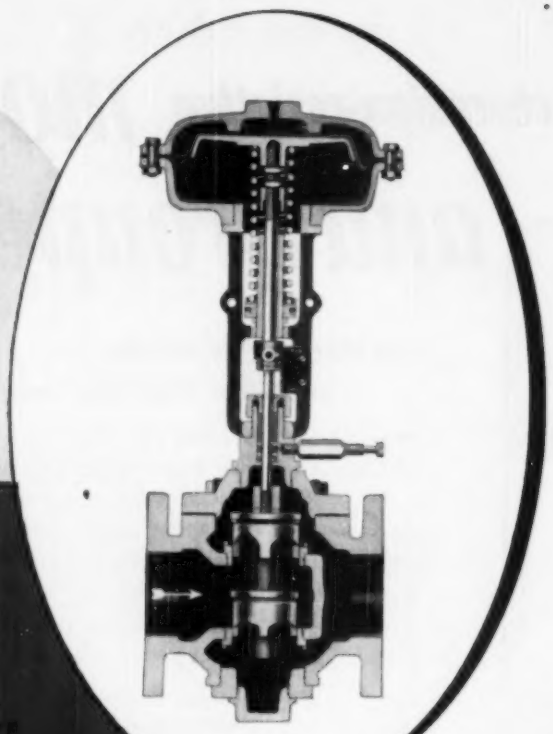
WHEN YOU'RE LOOKING FOR HIGH LIFT AND WIDE BAND PROPORTIONAL CONTROL...

Don't Overlook

The New

SERIES 77

DIAPHRAGM MOTOR VALVE



Here's an inexpensive high-lift valve with sensitivity and flow control characteristics normally found only in higher priced valves. It is ideal for automatic control installations where the controlled variable must be maintained within very close limits.

Outstanding features of the Series 77 include:

- *Negligible hysteresis in the superstructure . . . less than 2%.*
- *Equal percentage control characteristics with a 50 to 1 rangeability.*
- *Premolded Neoprene Diaphragm with patented Rolling Action.*
- *Lubricated stuffing box.*
- *Compact construction . . . requires little space for mounting.*
- *Inexpensive . . . in original cost and in upkeep.*

Your local Honeywell engineer is as near as your phone. Call him in for a discussion of the Series 77 in terms of your applications.

WORLD'S LARGEST ORGANIZATION FOR ADVANCED INSTRUMENTATION AND CONTROL

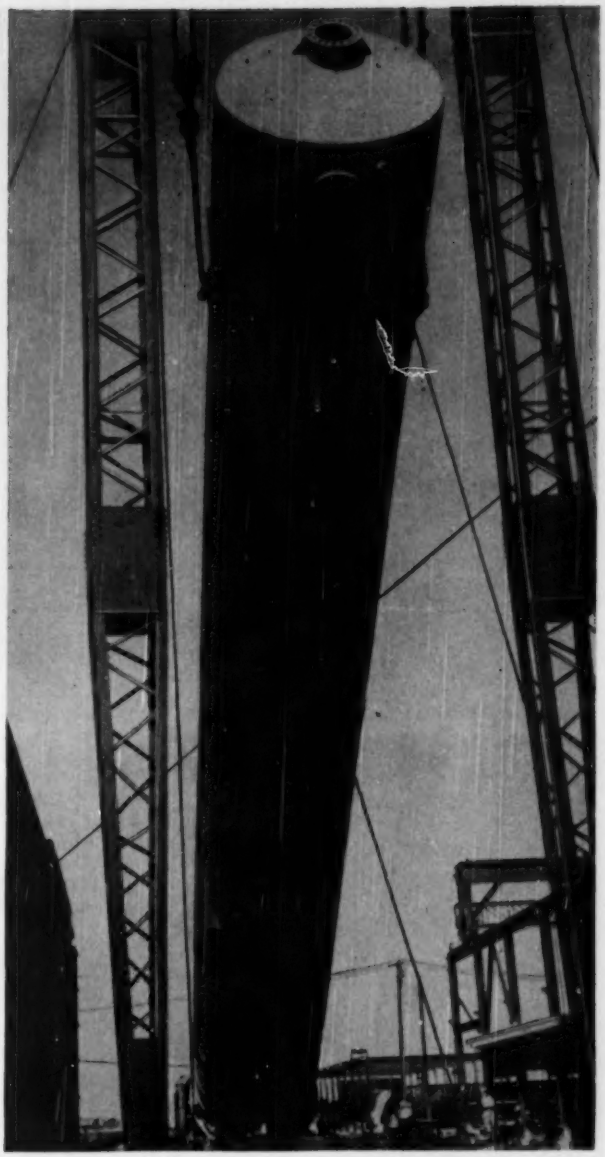
MINNEAPOLIS-HONEYWELL REGULATOR CO.
BELFIELD VALVE DIVISION
Philadelphia 44, Pa.
Offices in 77 principal cities of the United States, Canada and throughout the world

Honeywell — *Diaphragm Valves* AND PROCESS CONTROL SPECIALTIES — Belfield

MADE-TO-ORDER UNITS

for Petroleum and Chemical Processes

If you are a prospective purchaser of any such units, you will profit by consulting with Sun Ship. Here you have the benefit of long experience, exceptional skills and unlimited facilities. These facilities include our favorable location, because of which we can ship by water all units too large to be transported by rail . . . Also, the Sun reputation for building, reconditioning or repairing tankers and cargo vessels warrants your consideration when planning the overhauling or expansion of seagoing transport equipment.



Sun

SHIPBUILDING & DRY DOCK COMPANY

SINCE 1916

ON THE DELAWARE • CHESTER, PA.

25 BROADWAY • NEW YORK CITY

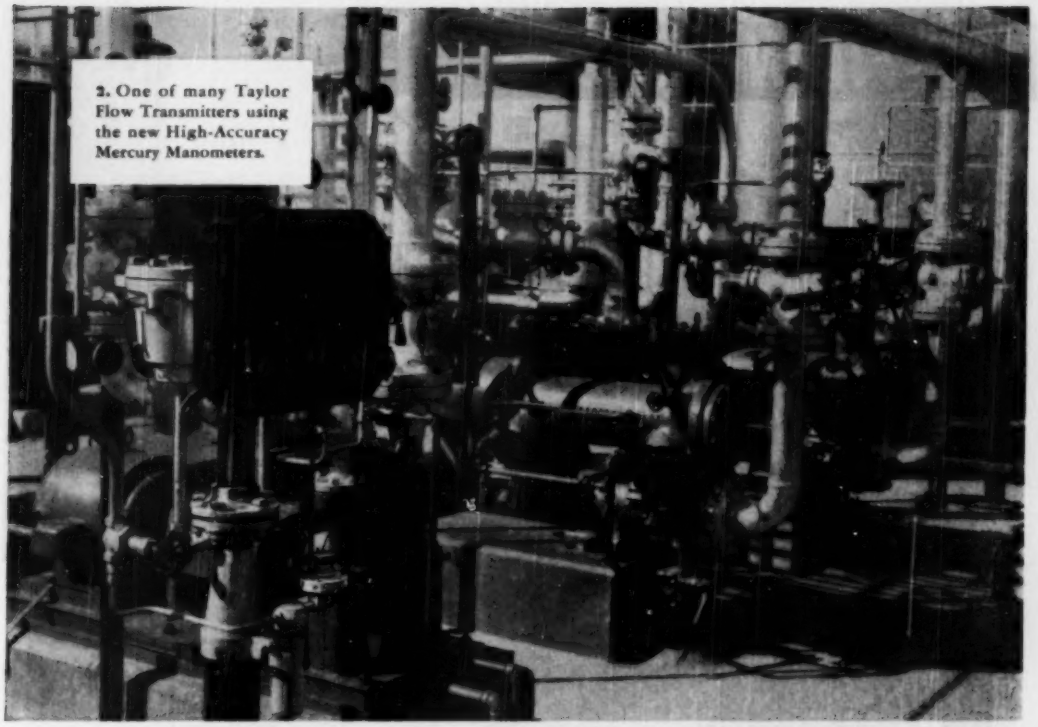
1. Central Control Panel at Gulf Oil Corporation's new natural gasoline plant, Odessa, Texas.

New Gulf Natural Gasoline Plant USES TAYLOR INSTRUMENTATION

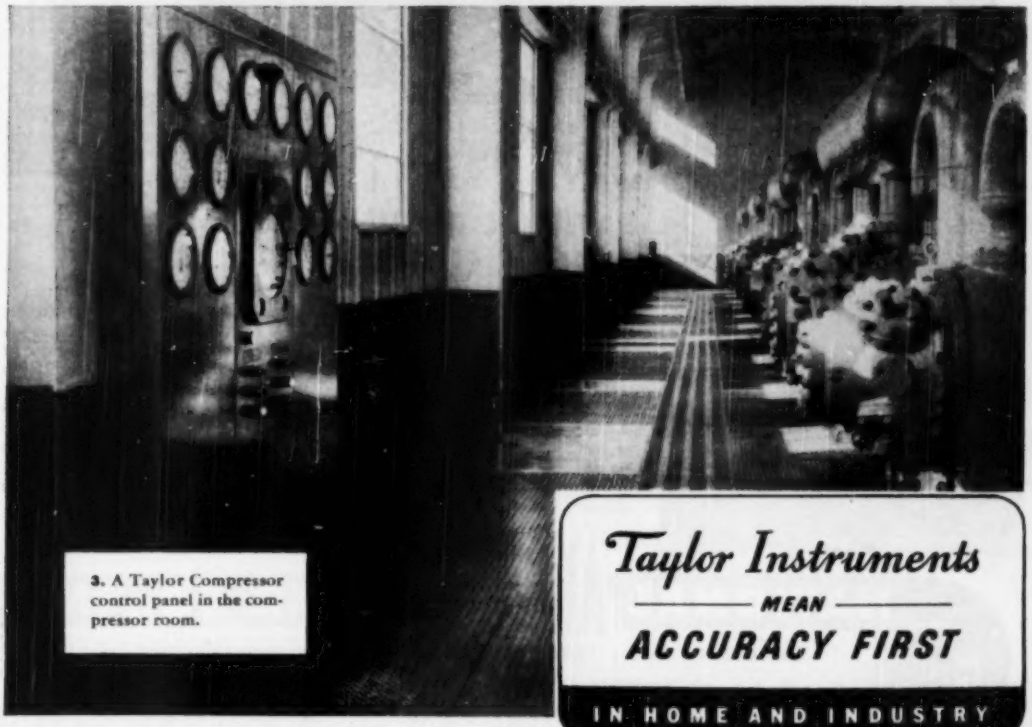
ONE of the show places of the Southwest is the Gulf Oil Corporation's new natural gasoline plant near Odessa, Texas. It now has a Taylor "brain" for measuring and controlling temperatures, pressures, flows and liquid levels. Remote pneumatic transmission systems were used to permit central panel boards. Back at the planning stage the Gulf Oil Corporation, consulting with C F Braun & Co and Bowden Construction Company, builders of the new plant, selected Taylor Instruments for the entire plant. They had the complete cooperation of Taylor Field Engineers from the selection stage to the tuning in of the instruments when going on stream.

The accuracy, simplicity and dependability of Taylor Instruments speak for themselves in terms of higher product quality and lower operating costs. Of particular interest to Gulf were the dependable performance and ease of maintenance of the new Taylor Flow Instruments with High-Accuracy Mercury Manometer with Teflon bearing. Whether your processing problems are simple or complex, there's a Taylor Instrument or control system and a competent Taylor Field Engineer to help you solve them. Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada.

Instruments for indicating, recording and controlling temperature, pressure, humidity, flow and liquid level.



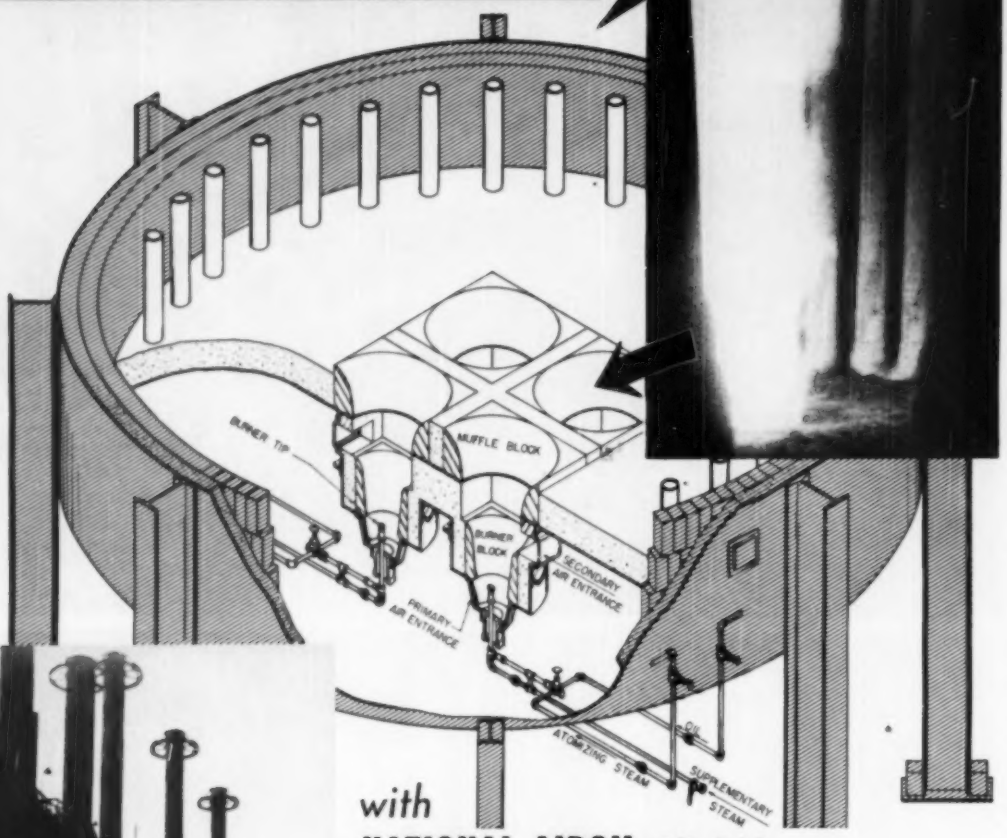
2. One of many Taylor Flow Transmitters using the new High-Accuracy Mercury Manometers.

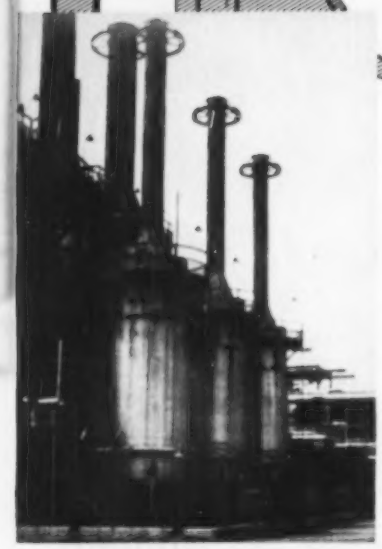


3. A Taylor Compressor control panel in the compressor room.

Taylor Instruments
MEAN
ACCURACY FIRST
IN HOME AND INDUSTRY

UP-FIRING FUEL OIL...





with

NATIONAL AIROIL OIL-GAS TANDEM COMBUSTION UNITS

The central drawing here is a cutaway view of "National Airoil" Vertical oil TANDEM COMBUSTION UNITS in an up-fired Petro Chem Heater. Unretouched photo at top right shows clean, even flame issuing from muffle block. Photo at lower left shows type of refinery furnaces where the installation of "National Airoil" TANDEM UNITS has proved widely popular throughout the petroleum industry.

The TANDEM UNIT has a high turn-down ratio with a steady flame . . . maintains high flame temperature with either fuel oil or gas; can be brought quickly to full capacity with a clean fire; and flame can be regulated to uniformly radiate heat to the absorbing surfaces without impingement.

Write for details about the Oil-Gas TANDEM COMBUSTION UNIT and the various types available.

NATIONAL AIROIL BURNER CO., INC.

Main Offices & Factory: 1254 EAST SEDGLEY AVENUE, PHILADELPHIA 34, PA.

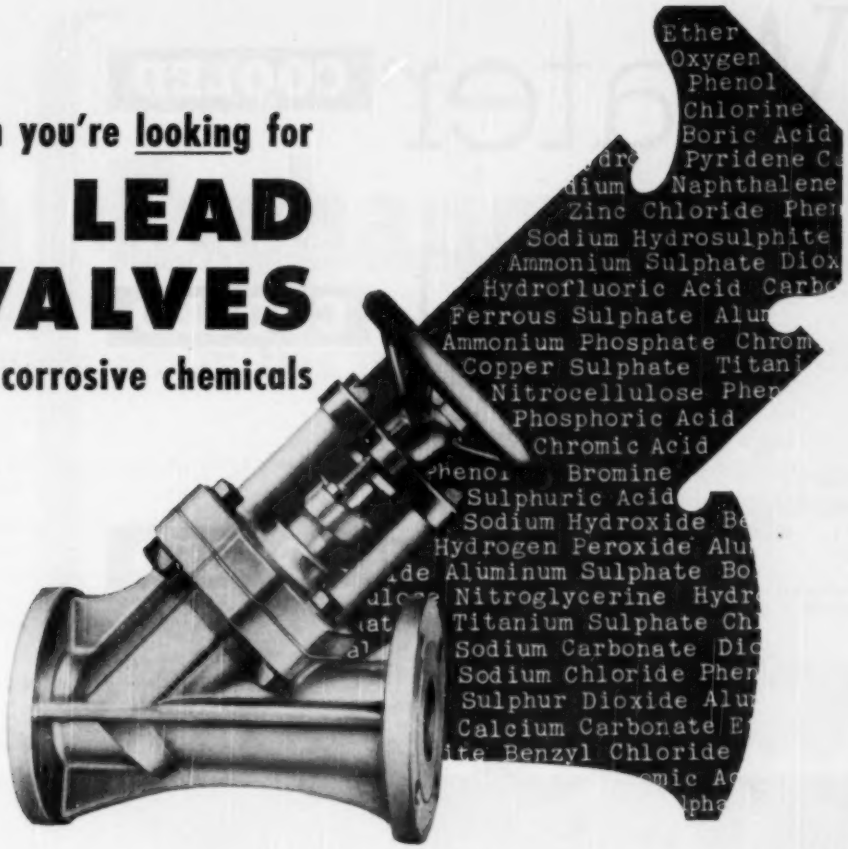
Southwestern Division: 2512 South Boulevard, Houston 6, Texas

INDUSTRIAL OIL BURNERS, GAS BURNERS, FURNACE EQUIPMENT

When you're looking for

LEAD VALVES

to control corrosive chemicals



Sturdiness, dependability, suitability... that's what you want in acid valves, isn't it?

And that's what you get in National Lead's "United" valves—valves made with "St. Joe chemical lead."

Sturdiness: National Lead valves are constructed to withstand stresses and overloads far beyond the demands of regular duty.

Dependability: The leader in lead, National Lead Company has the metal know-how... the acid control know-how... to design valves that make the most of lead's inherent corrosion resistance.

Suitability: To the selection of just the right valve, as well as the right alloys or other materials for critical parts, National Lead Company brings experience that covers the entire processing field.

Sturdiness, dependability, suitability... three good reasons for specifying National Lead's "United" valves. Available in a complete line that includes hard lead and lead-lined flanged acid valves; "Y" and angle patterns, gate, check, foot, and diaphragm valves.

Specify "United" whenever you need valves to control corrosive chemicals.

...look to the Leader in Lead

... in everything from lead pipe ... valves ... sheet ... and lead-lined or lead-covered equipment ... to complete acid recovery plants.

NATIONAL

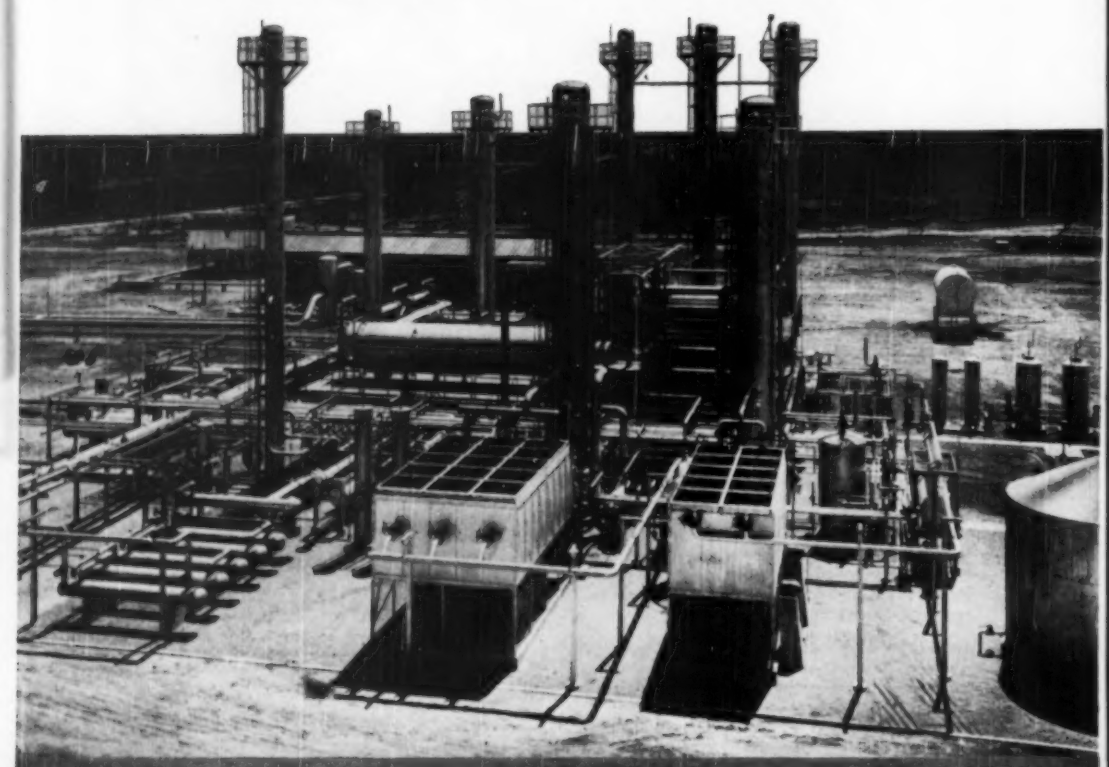
LEAD COMPANY

New York 6; Baltimore 3; Buffalo 3; Chicago 8; Cincinnati 3; Cleveland 13; Philadelphia 25; Pittsburgh 12; St. Louis 1; Boston 6 (National Lead Company of Mass.); Los Angeles 23 (Morris P. Kirk & Son, Inc.); Atlanta (Georgia Lead Works Div. of Cincinnati Branch); Toronto, Canada (Canada Metal Co. Ltd.).

Reg. U. S. Pat. Off.

Water COOLED
Oil COOLED
Air COOLED

G-R



GRISCOM-RUSSELL PIONEERS IN HEAT TRANSFER APPARATUS

Heat Exchangers

all 3 types are in this installation

Here's a striking instance of the broad range of G-R Heat Transfer Apparatus.

In this natural gasoline plant, the G-R equipment consists of *water-cooled* compressor intercoolers, still condensers and product coolers . . . *oil-cooled* lean oil exchangers . . . and *air-cooled* exhaust steam condenser and still reflux condensers.

In addition, the plant also uses G-R Reboilers and a G-R Type H Evaporator.

What does this mean to *you?* It indicates, first, that whatever may be your heat transfer processes, there is an exactly suitable G-R design. It indicates, secondly, that whatever may be your plant conditions, G-R can furnish the correct type of equipment to meet those conditions. And finally, it indicates that this plant, like many hundreds of others throughout the oil and gas industry, has preferred and standardized on G-R Apparatus for all heat transfer requirements.

Whenever *you* need heat transfer apparatus, consult the G-R engineers to be sure of best results.

THE GRISCOM-RUSSELL CO.

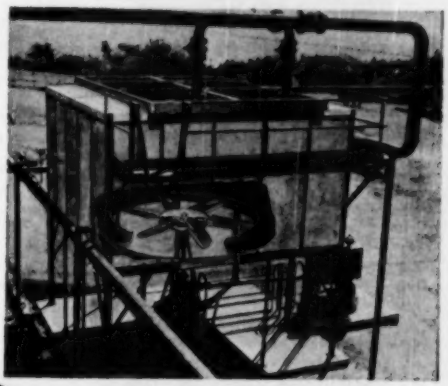
285 MADISON AVE., NEW YORK 17, N. Y.

G-R TWIN G-FIN SECTION

The most widely used heat transfer apparatus on the market. Adaptable to a broad range of heating, cooling, condensing and heat transfer services.

G-R TUBULAR HEAT EXCHANGER

Available with many different types of stationary heads, floating heads and baffle designs to meet service conditions to best advantage. Has many exclusive design features.



FIN-FAN EXCHANGER

Jointly developed by The Griscom-Russell Co. and Fluor Corporation Ltd., to provide an air-cooled unit suitable for cooling and condensing services wherever the water supply is insufficient or of poor quality.

GRISCOM-RUSSELL

GR-933

Homestead
LEVER-SEALD
Valves

ALWAYS WORK
LAST LONGER
COST LESS PER YEAR

STICKING valves are never a problem with Homestead Lever-Sealds on the job. Built into each valve is a powerful leverage, ready at all times to overcome the effects of corrosion, viscous fluids or temperature and pressure extremes which cause ordinary valves to stick or "freeze."

This powerful leverage not only relieves pressure between the seating surfaces to permit operation under all conditions; but it also is the means of providing the extra tight seal against leakage—the seal which keeps corrosive or erosive line fluids away from the seating surfaces; assures longer valve life and lowest cost per year.

Made in stainless steel, steel, semi-steel, bronze, monel or other alloys suitable for the working conditions under which they are to be used, Homestead Lever-Seald Valves may be had in sizes from 1" to 12"; and for working pressures from 150 pounds to 1500 pounds.

Choose the sizes and types for your services from Reference Book 39 Section 3. Write for your free copy today.

Check these Outstanding Features:

A QUARTER-TURN fully opens or closes valve.

INSTANT STICK-PROOF OPERATION. Plug turns freely after seating pressure is relieved by screw lever.

POSITIVE LEAKLESS SEAL is obtained by applying full seating pressure with screw lever after opening or closing.

LEAK PROOF. Deep stuffing box, gland and sealed bottom prevent fluid loss, and reduce hazards.

STRAIGHT-LINE FLUID FLOW. Little or no pressure drop.

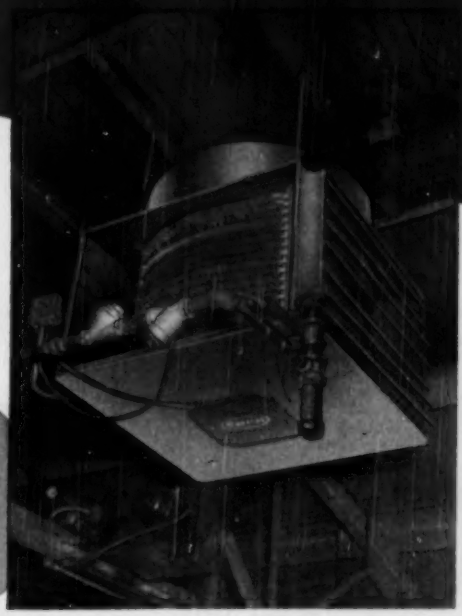
SEATING SURFACES ALWAYS PROTECTED in both open and closed positions. Fluid or grit cannot damage valve seat.

HOMESTEAD VALVE MANUFACTURING CO.

P. O. BOX 16 CORAOPOLIS, PENNA.

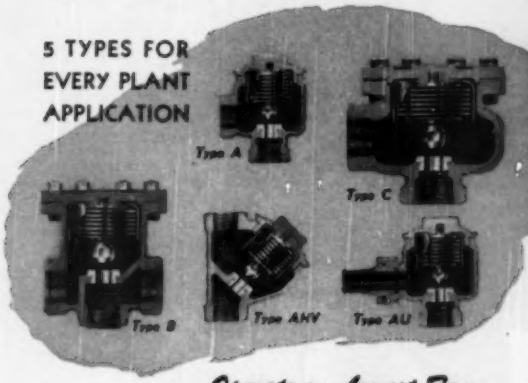
Stop COLD BLOW IN UNIT HEATERS

with Nicholson Steam Traps



"Cold Blow" means condensate back-up in the heater. Remedy? A faster-acting drainage trap. And comparative tests by large trap users show the Nicholson prevents cold blow because they operate on low temperature differential: 5° to 15°, depending on trap size and steam pressure.

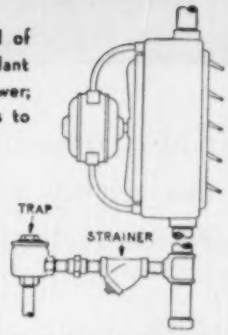
5 TYPES FOR EVERY PLANT APPLICATION



Operate on Lowest Temperature Differential . . . **NO WATERLOGGING**

Low temperature differential in the Nicholson steam trap is achieved by Nicholson's vapor-pressure-principle bellows. Extra large valve orifices provide great capacity. Thus, sudden load variations are quickly accommodated without condensate back-up. Valve stays open until steam arrives at trap. Their unsurpassed air-venting capacity also aid Nicholson traps in keeping equipment full of live steam. Types for every plant application: heat, process, power; size ¼" to 2"; pressures to 225 lbs.

At right is illustrated a typical hook-up of unit heater, Nicholson strainer and Nicholson trap. Send coupon for details of Nicholson's advanced features.



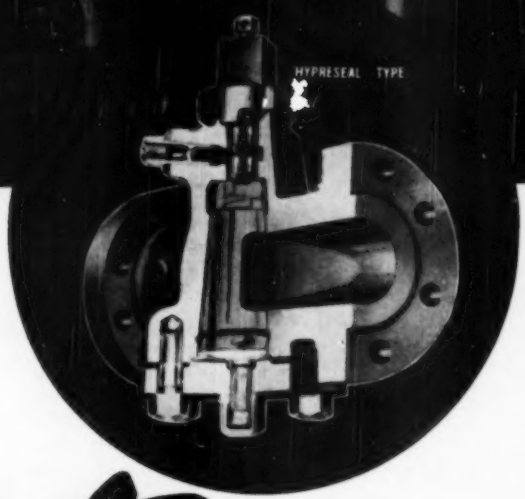
W. H. NICHOLSON & CO.

207 OREGON ST., WILKES-BARRE, PA.

W. H. NICHOLSON & CO. 207
Oregon St., Wilkes-Barre, Pa.
Please send Bulletin 1047 describing Nicholson steam traps.
Name ..... Position .....
Firm .....
Address .....

SEND FOR DATA ABOUT NICHOLSON'S ADVANCED FEATURES

FOREST OF STEEL - - -

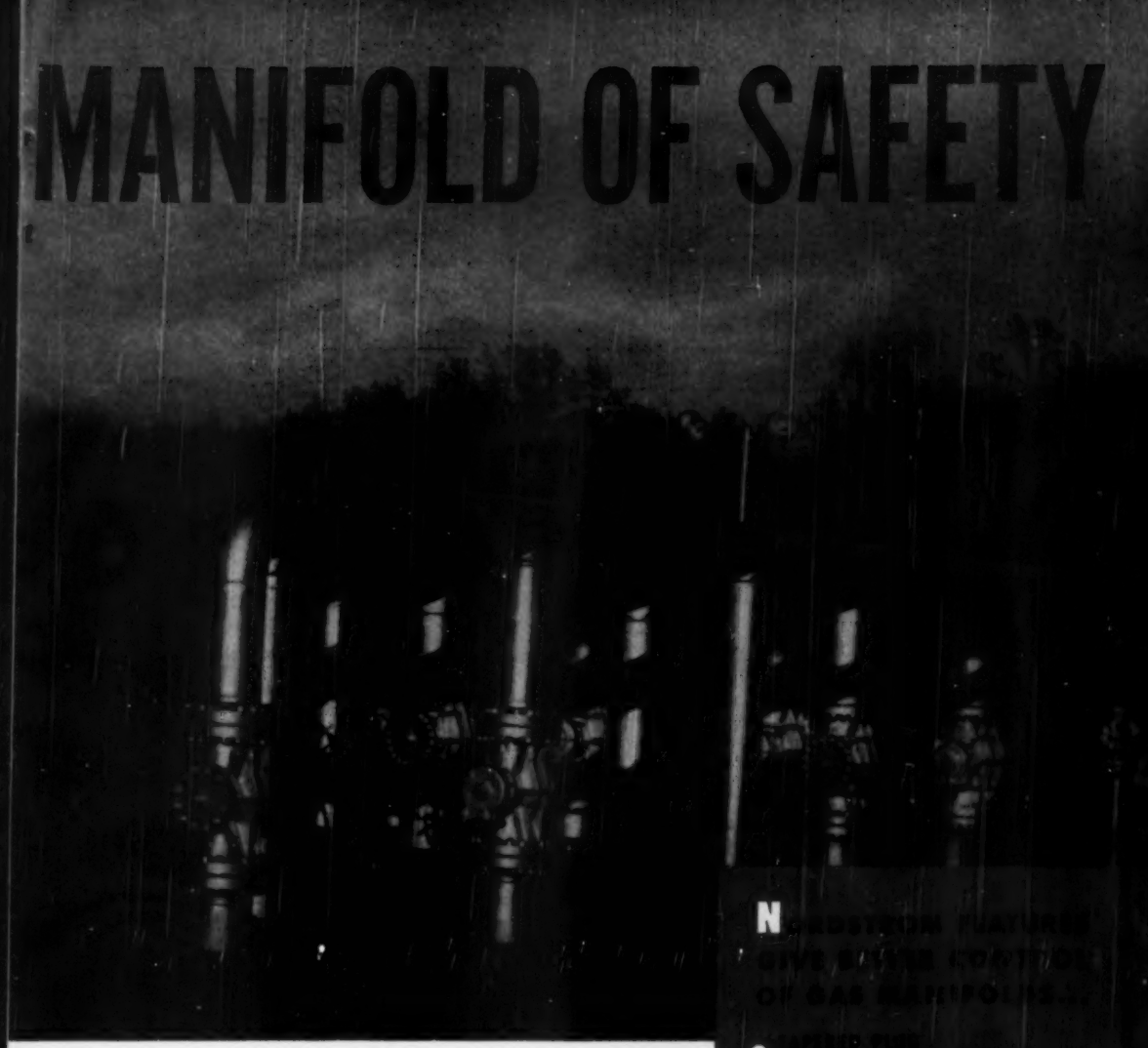


Good engineering as reflected in this mighty manifold makes Nordstrom selection a certainty.

Nordstrom

NOW AUTOMATICALLY LUBRICATED WITH Hypermatic
TRADE MARK

MANIFOLD OF SAFETY



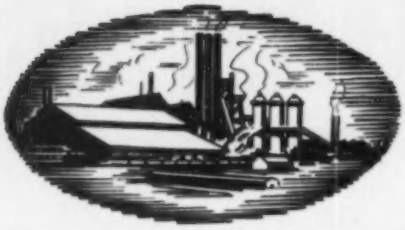
Satisfactory manifold operation demands quick switching, absolute certainty of full closure and ease of operation. When you install Nordstroms you can set your mind at ease—they give you every advantage of speed in operation and 100% safety. *Keep upkeep down.*

Valves

Nordstrom Valve Division — **ROCKWELL MANUFACTURING CO.**
400 North Lexington Avenue • Pittsburgh 8, Pa.

Atlanta, Boston, Chicago, Columbus, Houston, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco, Seattle, Tulsa . . . and leading Supply Houses
Export: Rockwell Manufacturing Co., International Division, 7701 Empire State Building, New York 1, New York

ROCKWELL



1900 ★ THE MIRACLE OF AMERICA ★ 1950

Freedom and Progress

It's no stretch of the imagination, rather, robust realism to call our past half century a Miracle—U. S. A.

America has set an amazing record of progress in 50 years—but a moment in the history of civilization. A record unequalled by any other political or economic system.

Merely by broad brush strokes, we can all visualize this miracle. Remember the crystal set, the hand-cranked car, the biplane? A far cry from our FM radio, television, hydro-matic drive and supersonic planes.

And here's another phase of the miracle that went hand-in-hand with these and the myriad of intertwined technological advances—ranging from the radio telephone and Bakelite to the X-ray tube and teletype . . . and to atomic energy and its untold potentialities.

- Since 1900 we have increased our supply of machine power 4½ times.
- Since 1900 we have more than doubled the output each of us produces for every hour we work.
- Since 1900 we have increased our annual income from less than $2400 per household to about $4000 (in dollars of the same purchasing power), yet . . .
- Since 1900 we have cut 18 hours from our average work week—equivalent to two present average workdays.

How did we do it? The basic cause for this composite miracle has been the release of human energy through FREEDOM, COMPETITION and OPPORTUNITY. And one of the most important results is the fact that more people are able to enjoy the products of this free energy than in any other system the world has ever known.

THIS IS THE MIRACLE OF AMERICA . . . it's only beginning to unfold.

A PUBLIC SERVICE PROJECT · THE ADVERTISING COUNCIL ·

Published in the public interest by PETROLEUM REFINER

High Pressure

MEETS ITS MATCH

Made from Alloy Steel—from the furnaces of Republic, world's leading alloy steel producer.

No matter how high the operating pressure, Republic Upson Alloy Steel Studs stay "on stream" without flinching. These tough, heavy-duty studs are built to hold fast under extreme operating conditions . . . built for complete dependability . . . built to stay on the job and keep maintenance costs at all-time lows.

They also provide positive resistance to corrosion and to elevated temperatures. Replacements? . . . You can be *sure* if you use Republic Upson Alloy Steel Studs. New equipment? . . . Why not *specify* them and forestall high pressure worries?

REPUBLIC STEEL CORPORATION
BOLT AND NUT DIVISION • CLEVELAND 13, OHIO
Export Department: Chrysler Building, New York 17, N. Y.

REPUBLIC *Upson Quality* **ALLOY STEEL STUDS**

REPUBLIC STEEL

Other Republic Products Include Machine, Tank and Carriage Bolts—Lag Screws, Cap Screws and Rivets

THE FRONTIER REFINING CO.

DENVER, COLORADO

CHEYENNE, WYOMING

Chooses

REFINERY ENGINEERING COMPANY

to Design, Engineer and Build their new Cheyenne, Wyoming Cracking & Coking Units

This will consist of a Recoil UOP Thermal Cracking Unit with integral coking facilities; a charging capacity of 2400 barrels and producing 105 tons of green coke per day. The unit will also have a charging capacity of 3500 barrels, producing 1560 barrels of railroad fuel oil daily. Wyoming 19 gravity reduced crude will be used as charging stock. All hot oil lines, internal surfaces of vessels, pumps and other auxiliary equipment subject to corrosion will be fully alloy protected.

The Frontier Refining Company is taking the lead in the Rocky Mountain area in establishing a full-rounded schedule of operations. Starting date was December 1, 1949 and estimated completion date is late spring of 1950.

TRECo

REFINERY ENGINEERING Company

PHONE 5-5561 • TULSA, OKLAHOMA

Cars used for testing are current models typical of the great majority on the road as well as others equipped with high compression ratio research engines.

Experimental fuels, stored under refrigerated conditions to maintain uniformity of volatility, are carefully checked before road testing.

DU PONT

BETTER THINGS FOR BETTER LIVING
THROUGH CHEMISTRY

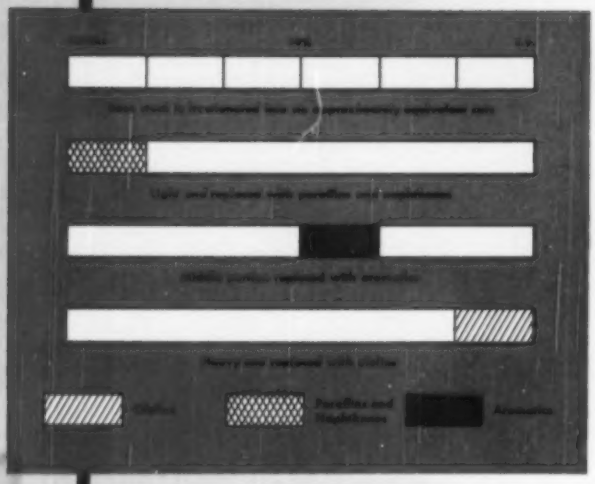
DU PONT
TETRAETHYL
LEAD
COMPOUNDS

Du Pont Research

Studying the Effects of Fuel Hydrocarbon Types on Road Antiknock Performance

As a service to the refining industry, Du Pont is now engaged in a program of fuel research designed to help provide answers to such questions as: how should fuel blending stocks rich in aromatics, naphthenes or other hydrocarbon types be blended to provide optimum fuel performance—where and how should they be blended to make most efficient use of tetraethyl lead compounds. This research project is devoted to studying the effects of fuel hydrocarbon types on road antiknock performance and is one of the most extensive of its type ever undertaken. Work on this study is now in progress and results will be available in the near future to assist refiners in their gasoline production.

Du Pont, as a supplier of tetraethyl lead compounds to a constantly increasing number of refiners, is working with the refining industry toward the common goal of improved gasolines for the motoring public at the lowest possible cost. Du Pont Petroleum Chemicals research is aimed at improving antiknock compounds and helping the refiner utilize present tetraethyl lead compounds most efficiently.



EXAMPLES OF HOW DIFFERENT HYDROCARBON TYPES ARE BLENDED TO PRODUCE EXPERIMENTAL FUELS

Working to help the refiner blend for the best possible utilization of TEL

As a starting point in the present Du Pont study of the effects of fuel hydrocarbon types on road antiknock performance a good quality regular grade gasoline was fractionated into six approximately equivalent cuts. Then each fraction was replaced systematically with pure hydrocarbons of three types (1) olefins, (2) paraffins and naphthenes and (3) aromatics (where possible). The components used in making these blends were selected so that the volatility of the finished blends was changed as little as possible and the research octane numbers of the unleaded blends were constant within plus or minus five units. The resulting blends, both clear and containing various amounts of TEL are being road knock tested in current model cars typical of the great majority on the road as well as in cars equipped with high compression ratio research engines. Thus data are being obtained on both present day and future requirements.

Such information will provide a better understanding of: (1) the effect on road antiknock performance and lead response of gasoline hydrocarbon type and position in the fuel boiling range and (2) the effects of engine design and compression ratio on the relative performance of basically different fuels. This project has a very practical value to the refiner because it will give him leads as to how he can best blend his stocks and make the best possible utilization of tetraethyl lead.

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING...*Through Chemistry*

E. I. DU PONT DE NEMOURS & COMPANY (INC.)
PETROLEUM CHEMICALS DIVISION
Wilmington 98, Delaware

District Laboratories: Wilmington, Del. · Chicago, Ill. · Tulsa, Okla. / Houston, Texas · El Monte, Calif.

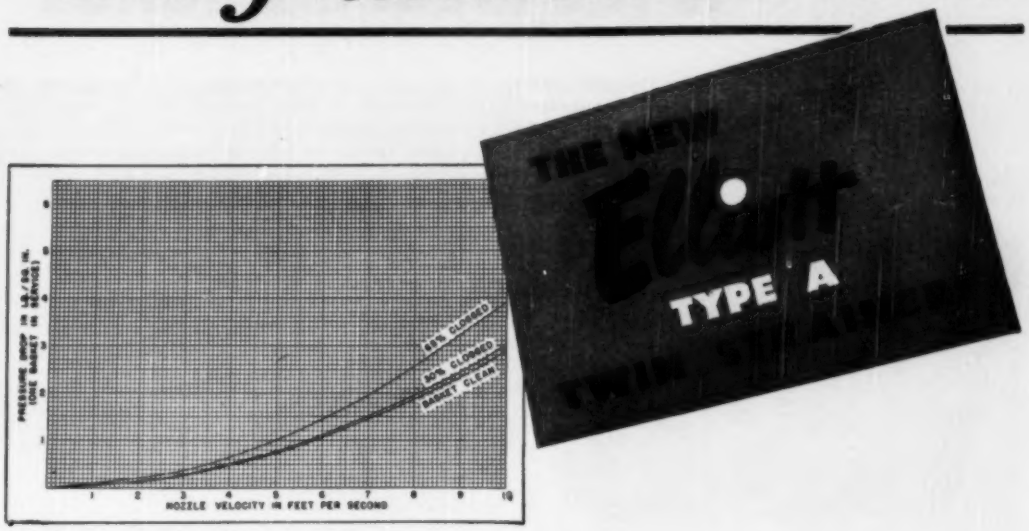
District Offices: Wilmington, Del. · Chicago, Ill. · Tulsa, Okla. / Houston, Texas · Los Angeles, Calif.

MAKE DU PONT THE SOURCE FOR ALL OF YOUR GASOLINE ADDITIVES...

- **TETRAETHYL LEAD COMPOUNDS** *(Motor Mix—Aviation Mix)*
- **ANTIOXIDANTS**
- **METAL DEACTIVATOR**
- **DYES**

A-9596

LOW *Pressure* DROP WITH



Result of a test made at the University of Pennsylvania's hydraulics laboratory to determine pressure drop in Elliott Type A Strainers.

STREAMLINE design of the strainer body and valve housings offers a minimum resistance to the flow of the liquid resulting in low pressure drop.

Larger basket area — approximately 5 to 1 ratio with standard mesh — further reduces the resistance to the liquid flow. This means a pressure drop of less than 2 feet of water at a velocity of 4.5 feet per sec when the basket is sufficiently clogged to require cleaning, as shown by the above curves plotted from tests on this strainer.

These new strainers have other advantages, too, in easier servicing, two-way gate valves that really seal, longer life, and most satisfactory operation all around. They're well worth checking into. Elliott Twin Strainers are available in sizes 1" to 24" for 125 lb pressure and 1" to 12" for 250 lb pressure. Full details in the interesting new bulletin, on request. Mail the coupon below.

Elliott COMPANY
Accessories Dept., JEANNETTE, PA.
Plants in JEANNETTE, PA. • RIDGWAY, PA.
SPRINGFIELD, O. • NEWARK, N. J.
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A-299-PR

ELLIOTT COMPANY
Accessories Dept. — Jeannette, Pa.
Please send me Twin Strainer Bulletin A-13.

Name _____

Company _____

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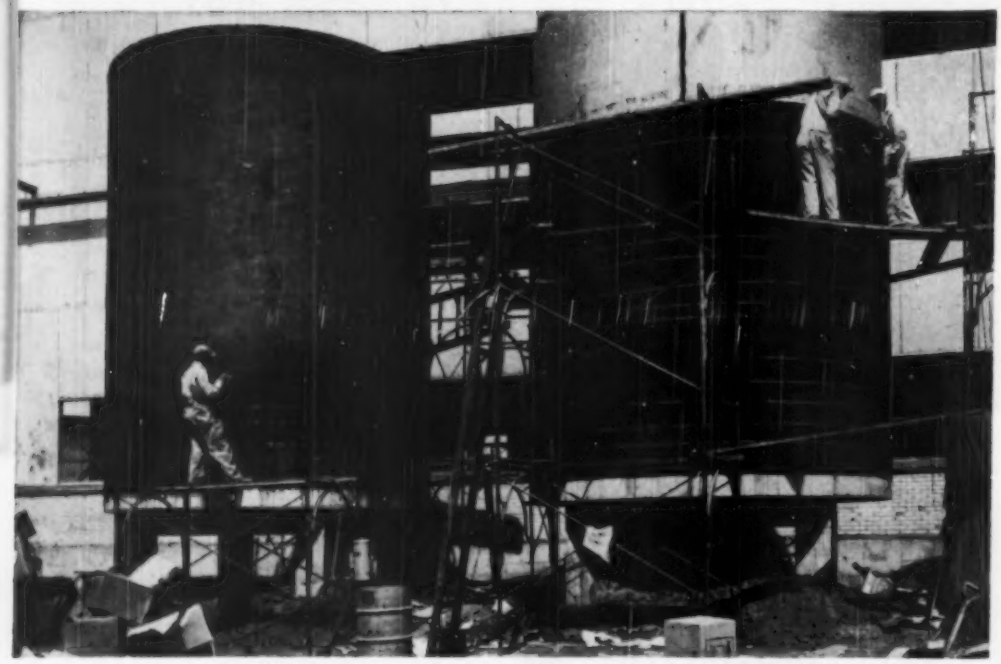
WHY PC FOAMGLAS is the ideal insulation

INDUSTRIAL plants throughout the country have come to rely on PC Foamglas to solve their most pressing insulating problems. They have found the unique properties of Foamglas make it the ideal insulating material for outdoor and indoor tanks, towers, retorts and other large vessels—for hot and cold piping, heat exchangers, evaporators and other processing equipment. Foamglas has especially proved itself in meeting the rigid requirements of the oil and gas, and chemical industries.

WHAT IS FOAMGLAS?

Foamglas is the only material of its kind, different from wools, boards and batts, the various fibrous and granular insulating materials with which you are already familiar. It contains no organic matter.

To make Foamglas, a very special kind of glass is subjected to a controlled heating process which produces strong, rigid blocks, composed of millions of tiny closed glass bubbles, full of still air. Because it is made of glass and because of its cellular structure, Foamglas is an exceptionally effective insulating material.

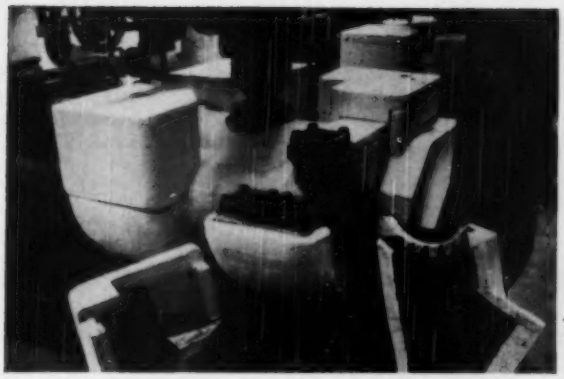


IN THIS INSTALLATION at the Minnesota Mining & Manufacturing Co., Inc., Hastings, Minn., PC Foamglas is being applied on phenol and formaldehyde tanks. Foamglas is available in standard flat blocks, curved segments and beveled lags to fit equipment sides, heads and domes, and in preformed sections for standard pipe sizes and fittings.

PITTSBURGH PC CORNING

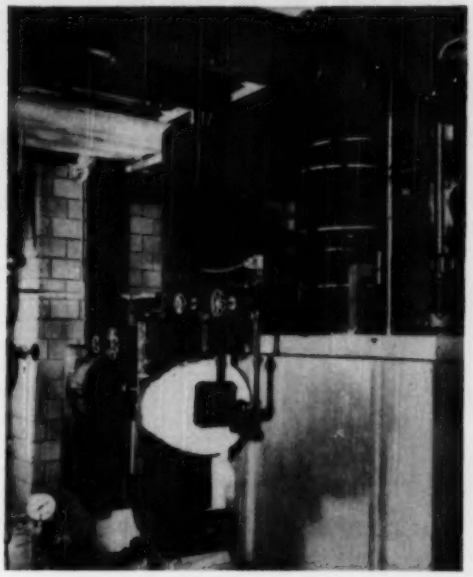
FOAMGLAS INSULATION

for industrial applications



◀ HERE, FITTING COVERS of PC Foamglas Insulation have been fabricated in the field from standard blocks. The sections, covered with Marine paper, are interlocking, can be removed easily from the reciprocating pump when desired. Photo courtesy of Socony-Vacuum Oil Co., Inc.

▼ IN THE NEW antibiotic building of Parke, Davis & Company, Detroit, Michigan, PC Foamglas Pipe and Fitting Insulation has been used on the pipe lines. A finish will be applied over the insulation and painted to match the interior color scheme.



LIGHT — STRONG — WORKABLE

PC Foamglas is lightweight, easy to handle. Durable and strong, it requires no expensive vapor and weather protection. Foamglas can readily be cut with a knife in straight lines or odd shapes. And because it's friable, when subjected to point loading, it yields to such surface irregularities as rivet heads and welds. Thus it can be pressed close to the area to be insulated without breaking or cracking; it can be shaped to curved surfaces of all radii.

MOISTUREPROOF — ACIDPROOF — FIREPROOF

Its continuous cellular structure does not permit moisture or vapor to penetrate or pass through Foamglas. It withstands high humidity, minimizes condensation. And, since Foamglas is a true glass, it is acidproof and fireproof. The latter characteristic is especially valuable where Foamglas is used as insulation with materials which are not fire-resistant.

FIRST COST IS LAST COST

You need fear no costly repairs, maintenance or replacements when you insulate with PC Foamglas. Being glass, it is impervious to many elements that cause other materials to lose insulating efficiency. In fact, when installed according to our specifications and recommendations, PC Foamglas retains its original insulating efficiency *permanently*.

Its ability to retard heat travel, to reduce condensation, to withstand humidity, makes Foamglas an exceptionally *effective* insulation. Freedom from repairs, maintenance and replacement makes PC Foamglas an exceptionally *economical* insulating material.

GET COMPLETE INFORMATION

Send for a sample of Foamglas. Test its light weight. Step on it. Cut it. Send the convenient coupon for our detailed, authoritative free booklet. Consult our insulating specialists regarding your insulating problems.

Pittsburgh Corning Corporation
Dept. T-20, 307 Fourth Avenue
Pittsburgh 22, Pa.

Please send me without obligation, a sample of PC Foamglas and your FREE booklet on the use of this *permanent* insulating material on industrial equipment.

Name_____

Address_____

City_____ State_____

When you insulate with Foamglas...you insulate for good!

WILFLEY
centrifugal PUMPS

...Economical for
SANDS, SLIMES, SLURRIES

WILFLEY · WILFLEY · WILFLEY · WILFLEY · WILFLEY · WILFLEY · WILFLEY · WILFLEY

Rubber and Metal Parts Interchangeable

Outstanding features of the WILFLEY pump include complete interchangeability of parts—from rubber to metal, or metal to rubber. Other exclusive features of design and construction, pioneered and developed by WILFLEY, give you stepped-up production, lower handling costs, and a proven dependability recognized by engineers all over the world. Wear parts are available in rubber, electric furnace iron and other materials individually engineered for every application. An economical size for every purpose. Write or wire for complete details.

A Companion
to the FAMOUS WILFLEY
Acid Pump

●

Buy WILFLEY for
Cost-Saving Performance

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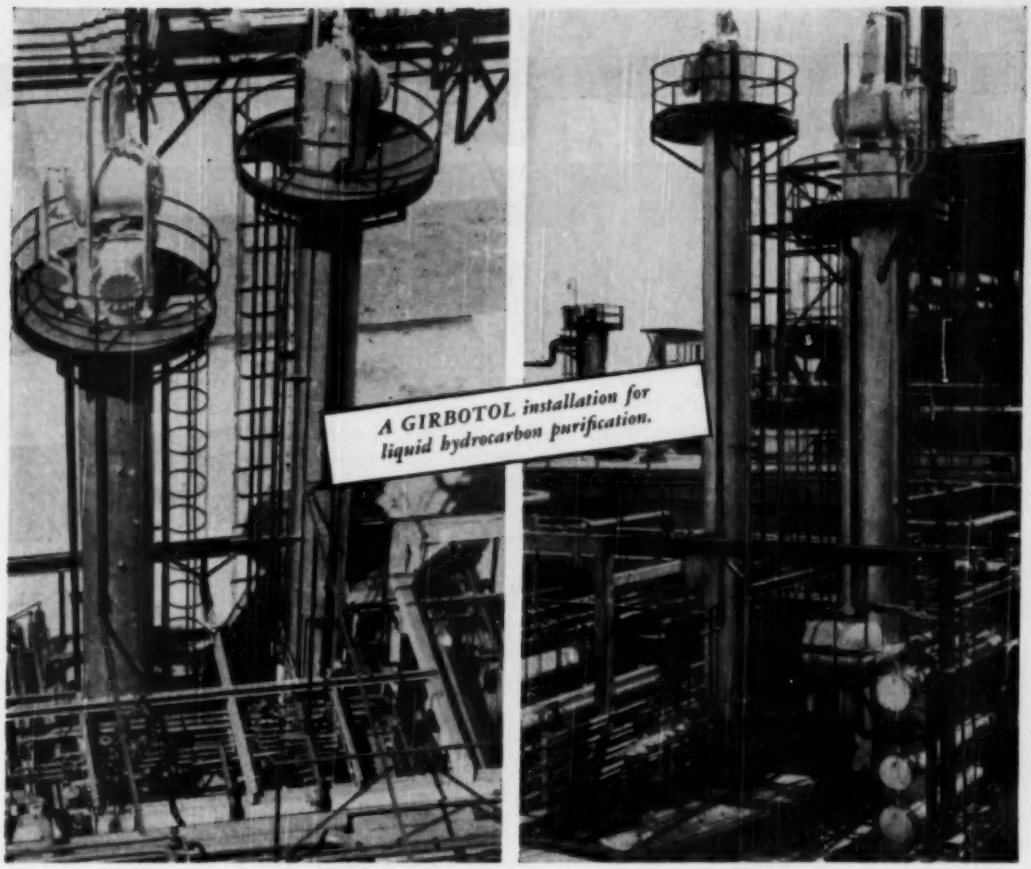
Denver, Colorado, U. S. A.
New York Office: 1775 Broadway,
New York City

WILFLEY
centrifugal PUMPS



A GIRBOTOL installation for liquid hydrocarbon purification.

Remove H_2S at low cost with a Girdler GIRBOTOL Plant

MORE AND MORE refiners are realizing the economics of the Girdler GIRBOTOL Process of hydrocarbon purification.

The GIRBOTOL Process is the *accepted* process for purifying gaseous refinery hydrocarbons. Now, more than a score of Girdler GIRBOTOL plants are being used to remove hydrogen sulphide from liquid hydrocarbons such as butane, propane, poly-feed stocks, straight-run naphthas and gasoline.

If you have a liquid stream that contains 500 pounds or more of hydrogen sulphide per day, you can save money with a Girdler GIRBOTOL plant!

Write or call us for Girdler engineering assistance on all problems involving gas manufacture, purification, separation or utilization.

Works speak louder than words

GAS PROCESSES DIVISION

THE GIRDLER CORPORATION

LOUISVILLE 1, KENTUCKY

DISTRICT OFFICES: 150 Broadway, New York City 7
2612 Russ Bldg., San Francisco 4
311 Tulsa Bldg., Tulsa 3
DESIGNERS, ENGINEERS AND CONSTRUCTORS

AUTOMATIC CONTROL EQUIPMENT

ENGINEERED DESIGN BY **HAMMEL-DAHL**

Spline Type Plugs mean flow control to the Last Drop!

"Fifteen" SPLINE TYPE SEAT GUIDED PLUGS are INTERCHANGEABLE in ½, ¾ and 1" Microflo Barstock Bodies. Trim is solid Stellite. The retained seat is type No. 12 and the plug is type No. 6 Stellite. The spline plug has a valve lift of 1", from the closed to the wide open position. Rangeability 30:1, or better, in all fifteen plugs. Equal percentage flow characteristics sizes No. 1 thru No. 5. Linear flow sizes No. 6 thru No. 15. Spline plug is a selective fit in a honed seat.

★ CONVERSION OF FLOW COEFFICIENT Cv TO CUBIC CENTIMETERS

From Size	Cv	CC
1	0.63	2385
2	0.40	1514
3	0.26	986
4	0.16	605
5	0.10	378
6	0.063	238.5
7	0.040	151.4
8	0.025	94.6
9	0.016	60.5
10	0.010	37.8
11	0.0063	23.85
12	0.0040	15.14
13	0.0025	9.46
14	0.0016	6.05
15	0.0010	3.78

★ The valve flow coefficient "Cv max." at one inch of lift, is equal to the rate of flow in GPM of water (or equivalent "cc") at one psi pressure drop across the valve body. The minimum flow will be 1/50 of Cv max., shown in the table.

HAMMEL-DAHL COMPANY

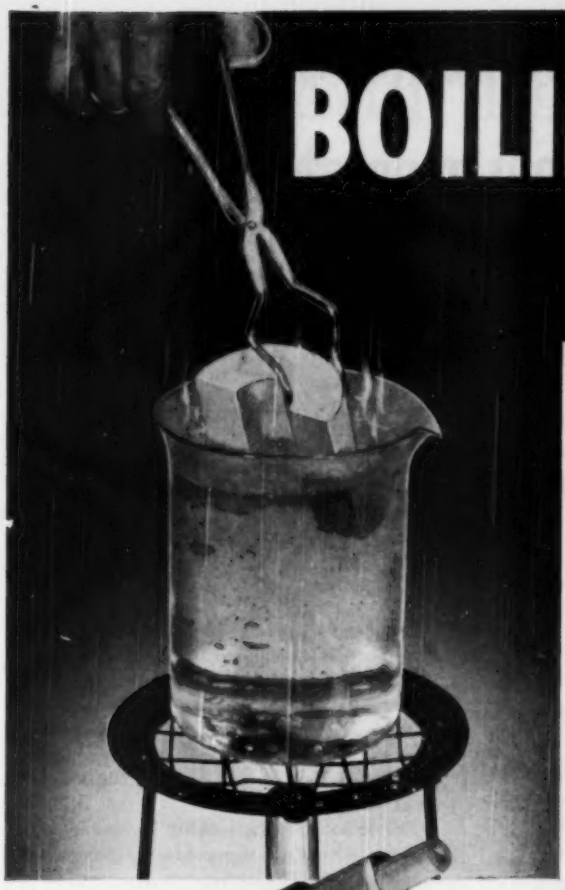
243 RICHMOND STREET, PROVIDENCE 3, R. I., U.S.A.

ALBANY BOSTON BUFFALO CHICAGO CINCINNATI CLEVELAND DETROIT
HOUSTON KINGSPORT, TENN. LOS ANGELES NEW YORK PITTSBURGH SAN FRANCISCO
SEATTLE ST. LOUIS SYRACUSE TOLEDO TULSA WILMINGTON, DEL.

In Canada, Railway & Power Engineering Corporation, Ltd.

BOILING TEST

PROVES STABILITY OF KAYLO HEAT INSULATION



What insulation material will not break down under exposure to live steam or hot liquid? Answer: Kaylo Heat Insulation.

In tests, samples of Kaylo Heat Insulation have been boiled continuously for 24 hours and longer. None has disintegrated or shown any loss of insulating efficiency, after drying. Test boiling has caused no appreciable shrinking, swelling, weight loss or permanent change in Kaylo Heat Insulation.

This Inorganic Material Insulates Efficiently From 200° F. to 1200° F.

One layer of Kaylo Heat Insulation assures you of insulating efficiency from 200°F. to 1200°F.—a temperature range which often requires two thicknesses of different materials . . . and the efficiency of Kaylo insulation actually improves after exposure to service temperatures.

This remarkable new product is available in two forms: Kaylo Heat Insulating Block and Kaylo Pipe Covering. Both are exceptionally strong, lightweight and resistant to moisture damage . . . easy to handle and apply . . . neat and clean in appearance on finished jobs.

The many advantages offered by Kaylo Heat Insulation are appreciated by users in many different industries.

KAYLO PIPE INSULATION is produced in Simplified Dimensional Standards of thicknesses and diameters for snug nesting, when necessary. Available in thicknesses from 1 to 3 inches in 36-in. sections, for pipe sizes from ½ to 12 in.

KAYLO®

HEAT INSULATING BLOCK and PIPE COVERING

OWENS-ILLINOIS GLASS COMPANY
Kaylo Division • Toledo 1, Ohio

SALES OFFICES:
Atlanta • Boston • Buffalo • Chicago • Cincinnati • Dallas • Minneapolis
New York • Philadelphia • Pittsburgh • St. Louis • Toledo • Washington

SEND COUPON FOR KAYLO HEAT INSULATION SAMPLE & LITERATURE

OWENS-ILLINOIS GLASS COMPANY
Dept. N-86, Kaylo Division · Toledo 1, Ohio

Gentlemen: Please send me a Kaylo Heat Insulation sample and descriptive literature.

NAME.....

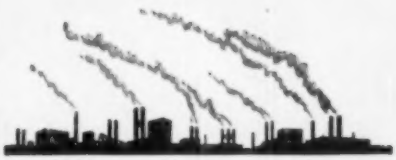
FIRM.....

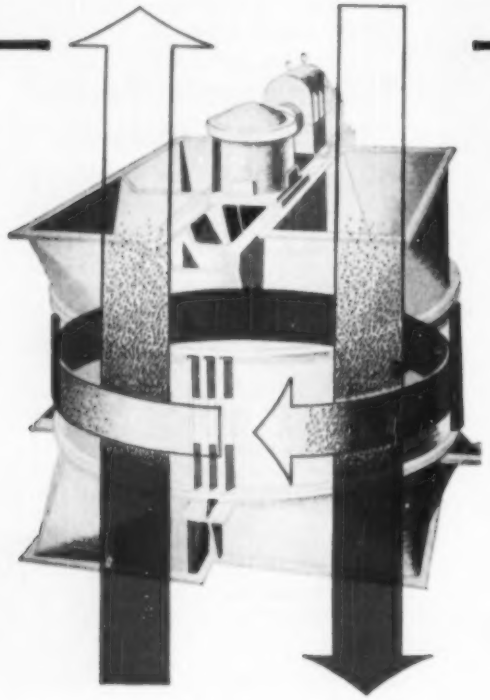
ADDRESS.....

CITY.....STATE.....

more than 160,000,000 lbs/hr of post-war steam generating capacity

equipped with *Ljungstrom*
AIR PREHEATERS





Here indeed is impressive evidence of the wide acceptance of the Ljungstrom air preheater. Since the war the total capacity of steam generating units equipped with Ljungstrom air preheaters, installed, under construction or on order in industrial and utility plants throughout the country comes to well over 160,000,000 lbs of steam per hr.

The reasons for the steadily increasing preference for the Ljungstrom air preheater are simple enough. The continuous regenerative counterflow principle assures maximum heat transfer with minimum weight and size. Flexible and compact, it may be used in a wide range of applications. Its proven reliability and low maintenance eliminate costly shutdowns.

If you are planning to build a new plant or modernize an old one, investigate the possibilities of the Ljungstrom. The specialized experience of Air Preheater engineers is at your disposal, to aid in effecting the most economic heat recovery from flue gases.

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves the heat is transferred from the waste gases to the incoming cold air.

THE AIR PREHEATER CORPORATION
60 EAST 42d STREET • NEW YORK 17, NEW YORK

No Stuffing Box Troubles–

BECAUSE THERE ARE NO STUFFING BOXES,

in

HAGAN

RING BALANCE METERS

The design of Hagan Ring Balance Meters eliminates stuffing boxes—and hence eliminates the troubles that go with them. Adjustment is less delicate, less maintenance is required; there is one less source of friction, hence greater sensitivity; there is no danger of leakage, therefore no way in which the fluid being measured can come in contact with any critical mechanism. No leakage means also that the meter stays in calibration over a much longer period.

Absence of stuffing boxes is, however, only one of the many important features of Hagan Ring Balance Flow Meters. They are rugged, sensitive, versatile—suitable for virtually every flow-metering application, including many applications which are almost impossible with conventional meters. For full information, write to Hagan Corporation, Hagan Building, Pittsburgh 30, Pennsylvania.

HAGAN CORPORATION

RING BALANCE FLOW AND PRESSURE INSTRUMENTS
THRUSTORQ FORCE MEASURING DEVICES
BOILER COMBUSTION CONTROL SYSTEMS
METALLURGICAL FURNACE CONTROL SYSTEMS

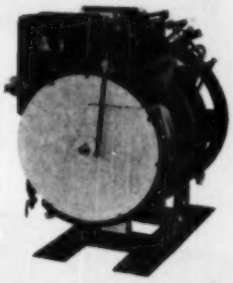
HAGAN HALL BUROMIN CALGON

SOME TYPICAL

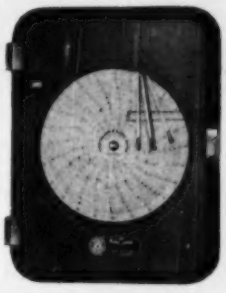
HAGAN

RING BALANCE METERS

Back view of single ring, high differential meter, showing S-tube connection.



Front view of dual meter with one high differential and one low differential ring.



Front view of three-pen meter in case. Panel space is the same for all models.

SW Headquarters for STANDARD and SPECIALLY DESIGNED Equipment

Absorber Tower 7 ft. I.D. x 69' 8" high, built according to API-ASME Code for 600# working pressure.

Absorber Tower 54" I.D. x 53' 6" straight shell, fabricated for 1000 PSI working pressure according to the rules of the API-ASME Code.

Naphtha Absorber Tower 5 ft. Dia. and lower part 7 ft. Dia. 103 ft. high straight shell. Bottom 7 ft. Dia. section lined with monel for corrosion resistance. Built in accordance with ASME Code, Para. U-68, for 390# working pressure.

Caustic Prewash Column 7' 6" I.D. x 35 ft. long. Straight Shell designed for 100 PSI at 650° F. maximum. Column for vertical use with ladders and platforms as required for operation.

Regardless of the type of equipment you need, the metals or alloys required for safe, economical operation, whether of standard or custom-built design, for pilot plant or field production—Struthers Wells engineers are in an excellent position to offer the best type for any service, no matter how unusual. Our engineering staff is available to cooperate with your organization without obligation.

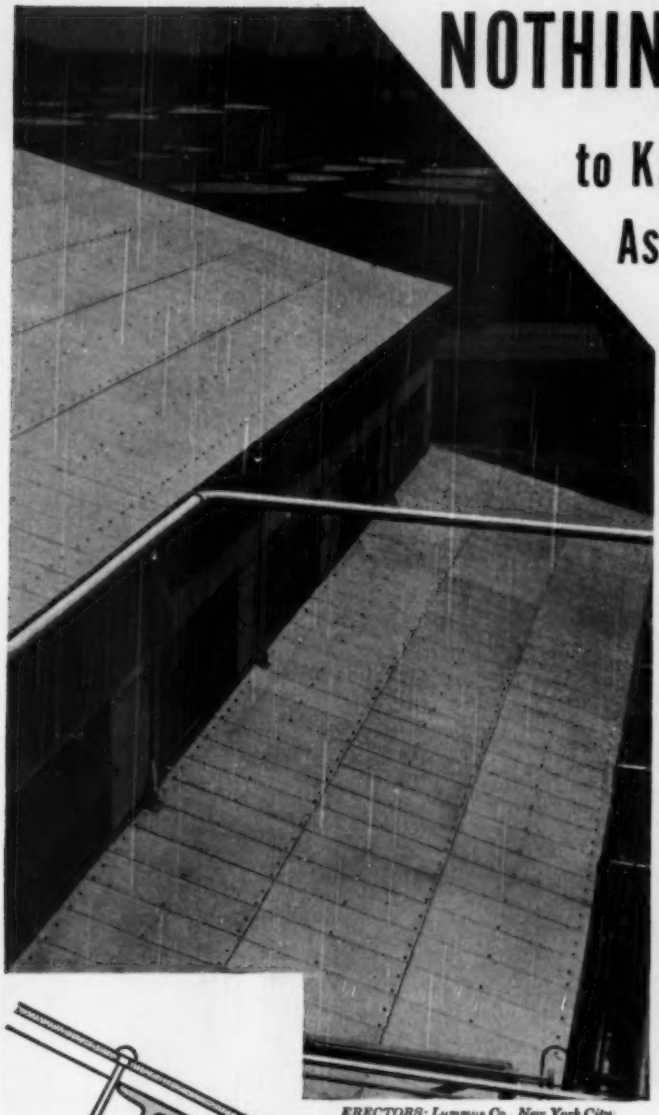
STRUTHERS WELLS
Corporation

Process Equipment Department • **TITUSVILLE, PA.**

Plants at Titusville, Pa. • Warren, Pa. • Offices in Principal Cities

NOTHING HAPPENS

to K&M *"Century"* Asbestos Corrugated



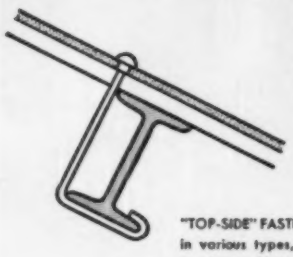
ERECTORS: Lummus Co., New York City.

Here you see it used for both the roofing and siding on this Shell Oil Company building at Deer Park, Texas. Don't ever expect to see it hurt by the weather or other adverse atmospheric conditions. Count on it to go rustless and rotless. It won't suffer from rodents and termites, and is exceptionally resistant to fire.

Easily cut and fitted on the job, K&M "Century" Asbestos Corrugated produces tight, good-looking surfaces at minimum labor cost. For extra savings use "TOP-SIDE"* fasteners, as on this Shell building. They entirely eliminate scaffolding and are only available with K&M "Century" Asbestos Corrugated.

Your finished job will benefit by the inherent structural strength of this material which actually gains strength with age. As for upkeep, you needn't figure on even one bit of paint!

*© H. & S. Enterprise Corp.

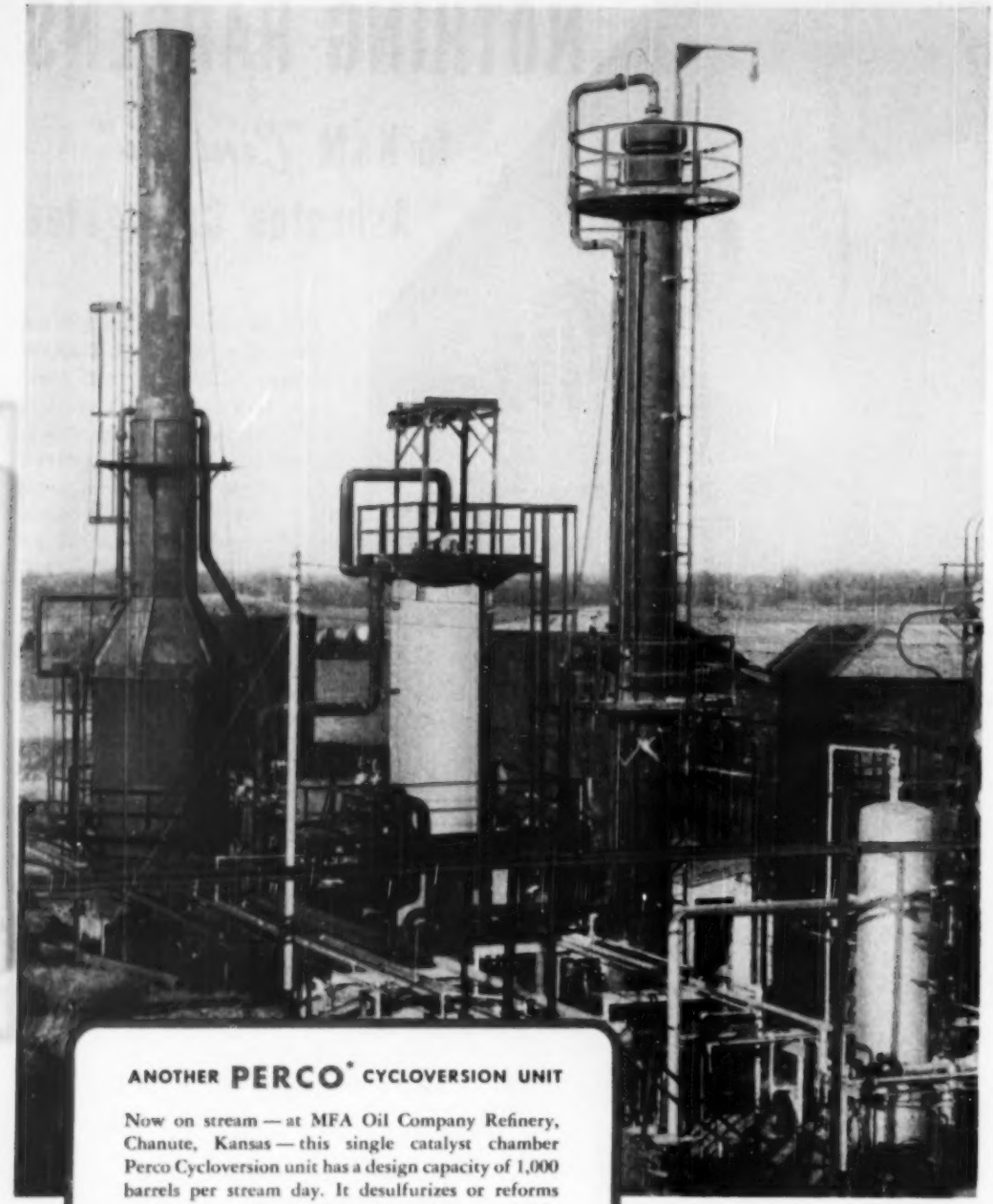


"TOP-SIDE" FASTENERS are made in various types, to fit all steel members on both roofing and siding. Illustration of typical "J" type for roofing.

Nature made Asbestos...
Keasbey & Mattison has made it serve mankind since 1873

K&M best in asbestos

KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA



ANOTHER PERCO* CYCLOVERSION UNIT

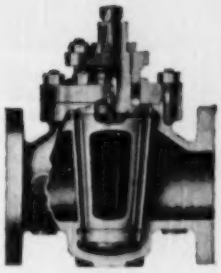
Now on stream — at MFA Oil Company Refinery, Chanute, Kansas — this single catalyst chamber Perco Cycloversion unit has a design capacity of 1,000 barrels per stream day. It desulfurizes or reforms straight run and cracked gasolines with remarkably low volume loss. Write us for full information.

PHILLIPS PETROLEUM COMPANY
PERCO DIVISION • CHEMICAL PRODUCTS DEPARTMENT
BARTLESVILLE, OKLAHOMA

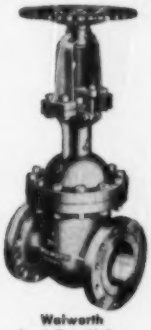
PROFIT WITH PERCO PROCESSES

*A SERVICE MARK

• VALVES
• PIPE FITTINGS



Walworth
Lubricated Plug Valve



Walworth
Steel Gate Valve

Walworth
Iron Body Gate Valve

Walworth
"500 Brinell" Bronze Globe Valve

Walworth
Iron Body Saddle Gate Valve

Walworth
Cast Steel Flanged Fittings

SINCE THE BEGINNING OF THE PETROLEUM INDUSTRY Walworth has been supplying producers and refiners with the quality products they demand . . .

The petroleum industry knows that years of engineering experience and development are back of all Walworth Valves and Pipe Fittings. Quality of workmanship, design and material are combined in every Walworth product to assure long years of trouble-free service.

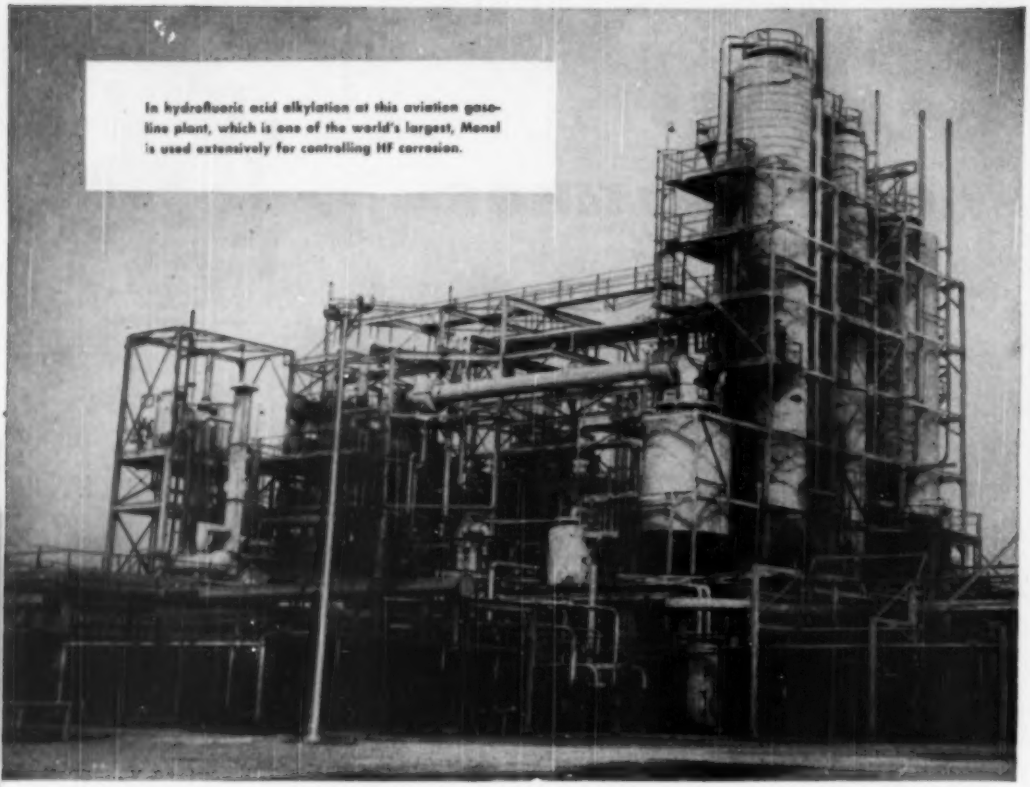
The valves and fittings shown here are typical of Walworth's complete line of steel, iron, bronze, and special alloy valves and fittings.

You can get all the facts about the complete Walworth line in the 600 page Catalog 47. Write for a copy.

WALWORTH
valves and fittings

60 EAST 42nd STREET, NEW YORK 17, N. Y.

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD



In hydrofluoric acid alkylation at this aviation gasoline plant, which is one of the world's largest, Monel is used extensively for controlling HF corrosion.

Specify **MONEL** *for handling* **HF** *and* **FLUORINE**

Experience has proved that for maximum safety, and corrosion resistance, Monel® is among the most satisfactory materials of construction for handling fluorine and its more active compounds.

Monel is highly resistant to ignition by fluorine. It has been successfully used to handle fluorine at pressures up to 400 pounds per square inch, and has shown economical corrosion resistance at temperatures up to about 900°F.

Not only is Monel highly resistant to attack by fluorine, it also shows good corrosion resistance to anhydrous hydrogen fluoride and to steam-HF mixtures, even at temperatures as high as 1100°F. A proven practical application of these facts has been the established use of Monel in hydrofluoric acid alkylation units in petroleum plants.

In addition to these excellent chemical characteristics are Monel's well-known physical properties: high strength . . . easy fabrication and welding. Important too . . . Monel is readily available in all standard mill forms and fittings.

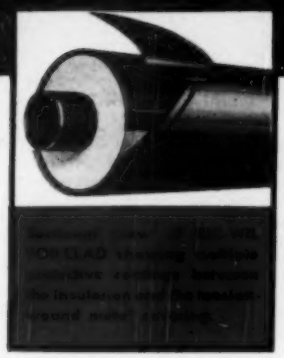
If your process requires the use of fluorine or fluorides, you will want to know more about Monel. For literature and additional technical data, write today.

EMBLEM OF SERVICE INCO TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

MONEL . . . for minimum maintenance

FOILCLAD . .



Multiple protective coverings add years of productive life and top thermal efficiency to FOILCLAD Insulated Piping.

INSURES DEPENDABLE TEMPERATURE CONTROL

Where processing requires absolute temperature control for all types of liquids, specify Ric-Wil Foilclad Piping Systems for all exposed applications.

The exclusive Ric-Wil construction of Foilclad insulating and protective coatings insures the thermal efficiency necessary to the processing of products requiring continuous temperature control.

Foilclad Insulated Piping provides extreme durability in operation and superior resistance to all kinds of weathering and corrosive atmosphere. The prefabricated standard sections and accessories make installation fast and provide great flexibility to fit system designs of all kinds.

An additional exclusive for users of Ric-Wil products is the "know-how" resulting from forty years of designing, engineering and production of insulated piping systems.

Our representative will provide detailed technical information on your specific problems at your request.

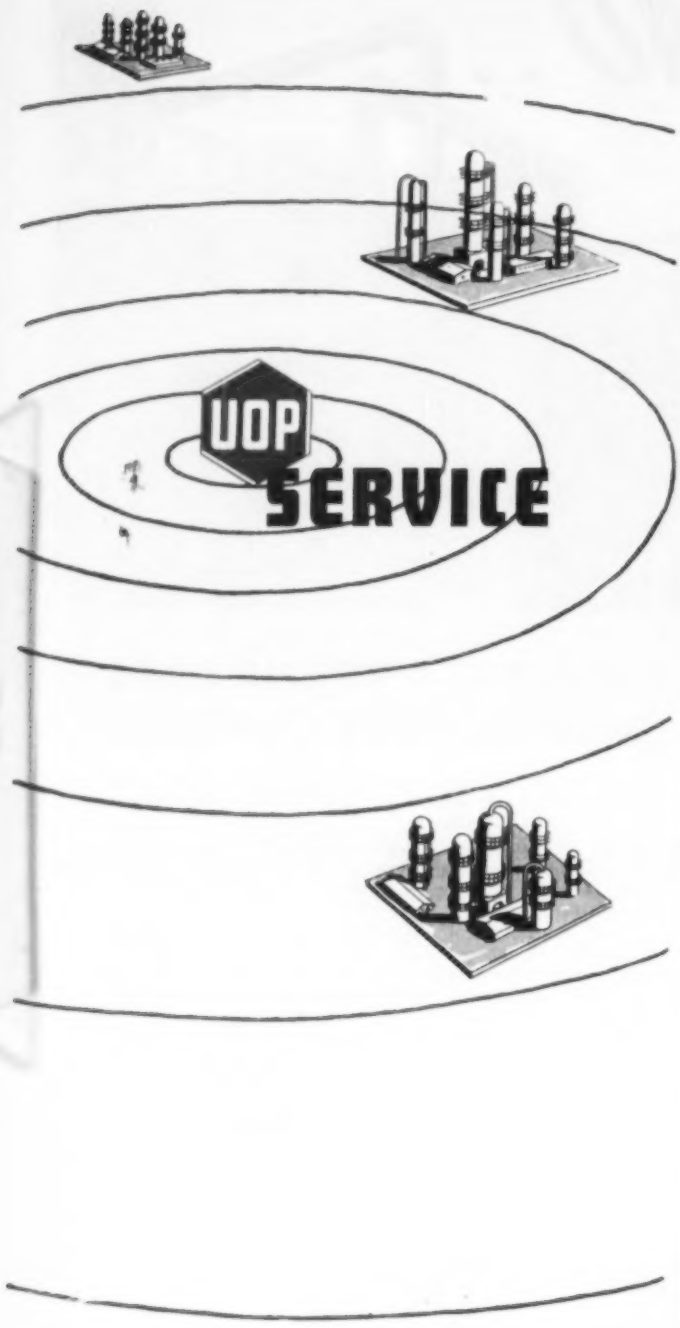
For full technical information on Ric-Wil Insulated Piping Systems, call or write the Ric-Wil office nearest you or Dept. 6-J in Cleveland, O.

RIC-WIL

INSULATED PIPING SYSTEMS

OVERHEAD — THE RIC-WIL COMPANY · CLEVELAND, O. — UNDERGROUND

FOR FORTY YEARS THE GREATEST NAME IN INSULATED PIPING SYSTEMS



Globe Boosts Capacity With Fluid Cat Cracker

By G. G. Woodruff
Secretary, Globe Oil & Refining Co.

By replacing a thermal cracking plant with the most modern type of fluid catalytic cracking unit and a gas concentration system, a major step has been taken in expanding the motor fuel producing capacity of our refinery at Lemont, Illinois, and substantially improving the octane rating of our gasoline.

G. G. Woodruff

The flexibility of the cat cracker also enables us to increase the yield of other light products, notably domestic furnace oil and diesel fuel, for which there is a growing demand. Production of heavy fuel oil, which is less desirable, has been reduced. With these improvements our refinery is in position to meet not only present octane requirements, but those anticipated in the forseeable future.

Unit Designed by Universal

When the installation of catalytic cracking facilities was first under consideration, all available processes were investigated from the standpoints of construction cost, yield and quality of gasoline and other products to be obtained. After thorough study, the design and engineering of the new facilities were entrusted to Universal Oil Products Company. The new unit, with a design capacity of 6,000 b/d, was placed on stream in early January.

Our Overall Operation

About 9,000 b/d of a mixture of West Texas, Wyoming and Gulf Coast crudes are charged to a combination atmospheric and vacuum distillation unit which produces about 2,800 b/d of gas oil. Approximately 22,000 barrels of a mixture of Illinois, Kansas and Gulf Coast sweet crudes are charged to a combination topping and gas oil cracking unit which produces about 3,200 barrels of a mixture of straight-run and cracked gas oils. The two gas oil streams, amounting to 6,000 barrels, are cracked in the new unit.

The overall refinery operation, including topping, cat cracking, desulfurization, thermal reforming and catalytic polymerization, produces about 17,800 b/d of gasoline or approximately 1,000 barrels more than was produced prior to the installation of the cat cracker. About 7,000 barrels of this gasoline are brought to Ethyl grade with 0.6cc of lead as compared to 1.8cc which we formerly used, while 10,800 barrels are marketed as housebrand gasoline with the addition of 1.1cc of lead. Other pro-

(Advertisement)

ducts are kerosene, diesel fuel, tractor fuel, furnace oil, heavy fuel oil, asphalt and road oil.

Here is a comparison of the yield from our old thermal unit and that which we expect from the fluid unit:

	Thermal Cracking		Catalytic Cracking (50% Conversion)	
	Bbl.	%	Bbl.	%
Gasoline (C_4 to 400°F)	1680	27.9	2860	47.8
Light fuel	1020	17.0	1800	30.0
Heavy fuel	3220	53.6	1200	20.0
Gas (Fuel oil equiv.)	186	3.1	440	7.3

The cat cracker is of the general UOP design with the reactor supported by a skirt set on the regenerator and with the stripper hung from the side of the reactor. The new graphic type control board, developed by UOP will be installed.

Low cost and reliable electric power is available to Globe, hence motor drives are used for the air blower and the gas compressors, as well as for most of the pumps. This results not only in lowered utility costs but also in a decrease in capital cost and maintenance.

Steam is used by the process for stripping catalyst and side cuts. This is exhaust from the main column bottoms circulating pump – the only turbine driven pump on the unit. A small amount of reboiler steam is also used for a few small reciprocating pumps and for a small reboiler in the gas recovery unit.

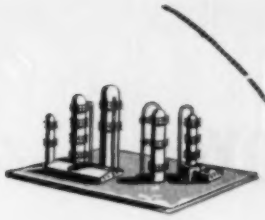
The Gas Concentration System

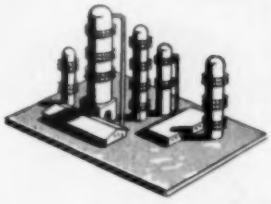
Steam is generated from waste heat in the regenerator flue gas and the column bottoms. After furnishing steam to the catalytic cracking and gas recovery units, about 10,000 lb./hr. is supplied the refinery for use in crude and vacuum units. The gas concentration system is of the deethanizer type. Its two functions are the preparation of feed for the catalytic polymerization unit and the debutanization of catalytically cracked gasoline; hence, it is designed for maximum recovery of propane.

The system consists of a compressor section, a deethanizer and a debutanizer. Two existing towers were adapted to the deethanizer service.

In operation, the gas from the catalytic cracker receiver is compressed in two stages to 200 lb. per square inch and is charged to an absorption type deethanizer. The overhead from this tower is ethane and lighter gas which is discharged to the fuel gas line. The bottoms are charged to the debutanizer which operated at 150 lb. pressure. The debutanizer overhead is composed of C_3C_4 fractions, which constitute the charge to the poly unit. The bottoms normally are debutanized gasoline. The unit is designed for very high heat efficiency, reboiler requirements being supplied almost entirely by heat exchange from a cat cracker side-cut and debutanizer bottoms.

(Advertisement)





An ever-widening influence on the success... present and future... of refineries everywhere

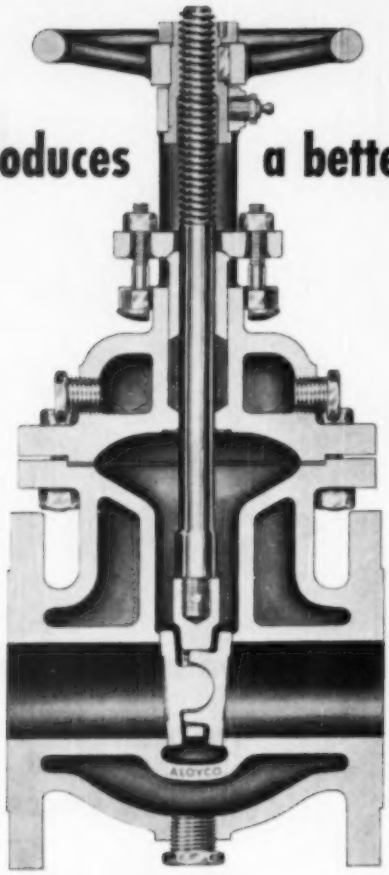
UNIVERSAL OIL PRODUCTS COMPANY

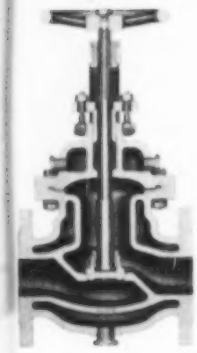
UOP

General Offices: 310 S. MICHIGAN AVE., CHICAGO 4, ILLINOIS, U.S.A.
LABORATORIES: RIVERSIDE, ILLINOIS

Universal Service Protects Your Refinery

ALOYCO introduces a better jacketed valve in stainless steel and corrosion-resistant alloys





● Aloyco Jacketed Valves are made in three basic styles: Gate (No. 1105), Globe (No. 1305) and Check (No. 1505). Jacketed flanged tees and 90° elbows are also available in straight sizes.

HERE are the first *completely* jacketed valves in solid alloy. They are recommended for accelerating the flow of viscous liquids where corrosion is a factor. Their performance is outstanding with phthalic and maleic anhydrides, rosin and resins, tars and tar oils, molten sulfur, and many other fluids difficult to move at room temperature.

The sectional views illustrate the thoroughness of Aloyco jacketing. Note how it extends to the edges of the flanges. Also, observe that the bonnets are fully jacketed, as well as the bodies. In designing these valves, our engineers have retained all the Aloyco standard features, such as double disc wedges which are non-fouling and are pressure-tight on both seats. Aloyco Jacketed Valves are the embodiment of engineering, pattern-making and foundry skills of a high order.

Send for our new Bulletin No. 3.

Aloyco Valves are manufactured in compliance with the new MSS Stainless Steel Valve Standards S.P.-42.

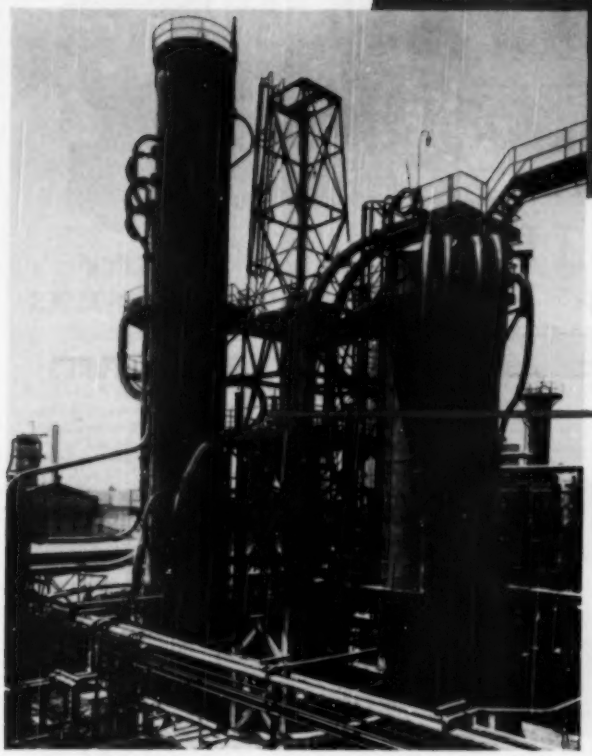
ALLOY STEEL PRODUCTS CO., Inc.

1303 W. ELIZABETH AVE., LINDEN, NEW JERSEY

ATLANTA — CHICAGO — HOUSTON — LOS ANGELES — NEW YORK — PITTSBURGH — WILMINGTON

TRET·O·LITE

Chemical
DESALTING



makes refinery operations *more efficient* *more economical*

By reducing the salt content of charging crudes to a minimum, the Tretolite desalting process helps to eliminate the costly troubles caused by salt. If severe corrosion, plugging and hard coke formation are decreasing your on-stream time and increasing your maintenance costs, why not get in touch with Tretolite? Preliminary tests and a salt survey do not obligate you.

Tretolite Desalting offers these facilities—

Preliminary desalting survey
Laboratory pilot tests
Competent plant design
Construction consultation
Start-up assistance
On-call service

Tretolite Desalting protects against—

Salt plugging
Corrosion from evolved HCl
Hard coke formation
On-stream time losses
High maintenance costs
Impaired equipment efficiency

The Tretolite Company also offers these specialized services to refiners:

Water clarification chemicals · Demulsifiers for waste oil emulsions · Corrosion preventive chemicals · Corrosion resistant coatings · Demulsifiers and foam preventers for use in doctor treating and other sweetening solutions

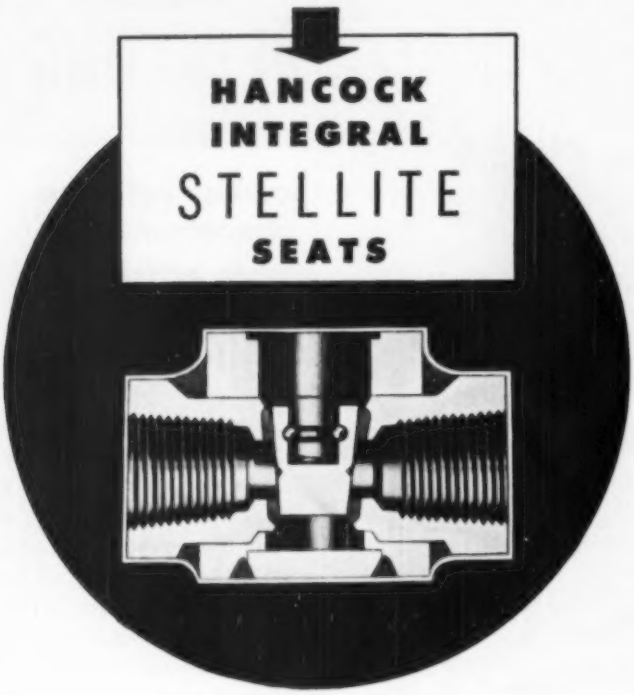
TRETOLITE COMPANY ST. LOUIS 19, MO.

CHEMICALS FOR THE PETROLEUM INDUSTRY

Dehydrating · Desalting · Water De-Oiling · Corrosion Inhibition Scale Prevention · Paraffin Removal

TDSD-1

UNLIMITED SERVICE-LIFE *is just* ONE ADVANTAGE *of*



When you install **HANCOCK GATE WELDVALVES...**

you are assured of freedom from valve seat leakage and replacement! For Hancock's integral stellite seats positively prevent leaks between body and seating surface, never need to be renewed! They guarantee valve service-life far beyond requirements of the equipment on which the valves are used.

HANCOCK GATE WELDVALVES *give you these* PLUS FEATURES!

DISSIMILAR MATERIALS In Seats and Wedges mean an extra guarantee of long-life, no galling! Perfect alignment and tightness assured.

SELF-STORING GLAND is a real "plus" for the operator! No wiring, no tying in place and plenty of room and length along the stem to get at the packing.

NO STEM PITTING because stems in all Hancock Gate WELDVALVES are completely coated with a heavy cadmium plating!

YOKE POST and Gland Nut Threads Protected regardless of years of service, corrosive atmospheres! A number of threads on the yoke post studs are always covered, protected, workable.

PACKING EASE because there's plenty of packing space, packing of the highest quality, packing for the widest range of services.

SAFE HANDWHEEL protects the operator in "hot" services!

INTERCHANGEABLE PARTS. All wedges, stems and thread bushings made to exacting uniformity!

CORROSION RESISTANT Back Seating allows stuffing box shut-off around stem when fully opened!

BAKED ENAMEL Exterior Finish means maximum protection from corrosion of all external parts.

You can depend upon your Hancock Distributor for prompt service

MAXWELL MANNING & MOORE INC. TRADE MARK

HANCOCK *Valves*

1877 HANCOCK U.S.A.

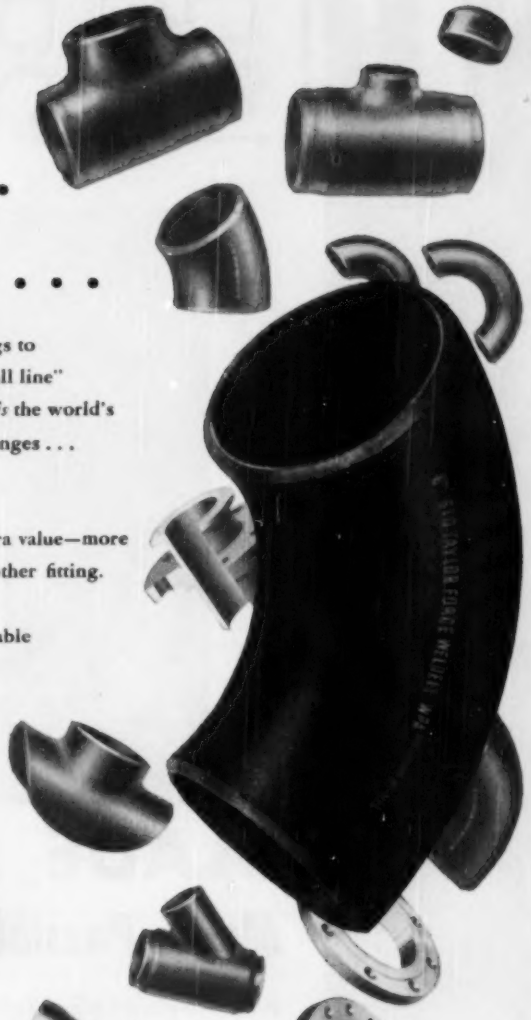
A PRODUCT OF

MANNING, MAXWELL & MOORE, INC.

WATERTOWN 72, MASSACHUSETTS

Makers of 'Hancock' Valves, 'Ashcroft' Gauges, 'Consolidated' Safety and Relief Valves, 'American' Industrial and 'Microsen' Electrical Instruments. Builders of 'Shaw-Box' Cranes, 'Budgit' and 'Load-Lifter' Hoists and other lifting specialties.

FULL LINE . .
FULL VALUE . . .
FULL SERVICE . . . .



We have repeatedly urged users of welding fittings to accept no less than the *full line.* When we say "full line" we don't just mean its *completeness* . . . though it *is* the world's most complete line of forged steel fittings and flanges . . . and it *does* contain the widest range of types, sizes, weights and materials.

When we say "full line" we mean full value—extra value—more and better features than can be found in any other fitting. The technical brains and forging skills which conceived these extra values continue to be available to you through the Taylor Forge organization, and through the Taylor Forge distributor who is your industrial neighbor.

Since Taylor Forge welding fittings "have everything," why compromise on less than the best?

TAYLOR FORGE

TAYLOR FORGE & PIPE WORKS General Offices & Works: Chicago 90, Ill. (P.O. Box 485) Eastern Plant: Carnegie, Pa. Western Plant: Fontana, Calif. • District Offices—New York: 50 Church Street • Philadelphia: Broad Street Station Bldg. • Pittsburgh: First National Bank Bldg. Chicago District Sales: 208 S. LaSalle Street • Houston: City National Bank Bldg. • Los Angeles: Subway Terminal Bldg. • San Francisco: Russ Bldg.

Do your piping specifications create any fitting or flange problems for you? . . . . . If the information you need just doesn't appear in the course of the pages of this data, please write us today. You will receive a prompt and detailed reply.

☐ Who is my nearest Taylor Forge Distributor?

☐ Put my name on your mailing list to receive informative literature.

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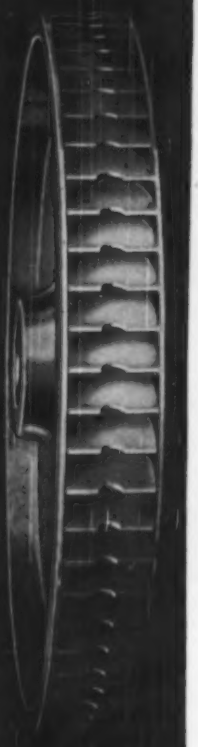
TERRY



BLADE PROTECTION

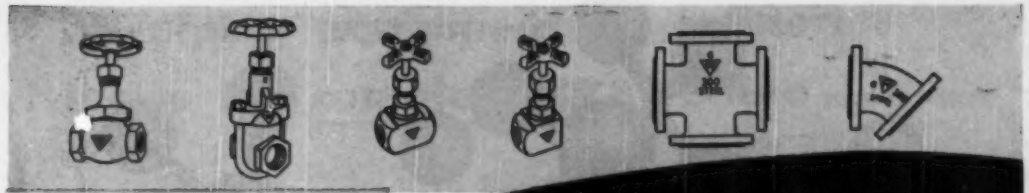
Made Possible by Nozzle Location

In the Terry Solid-Wheel Turbine, the steam enters the buckets from the top, not from the side of the wheel, as shown in the illustration above. This permits a one inch clearance on either side of the wheel. In addition, projecting rims on each side of the buckets prevent damage to the blades even though excessive thrust should tend to move the shaft.

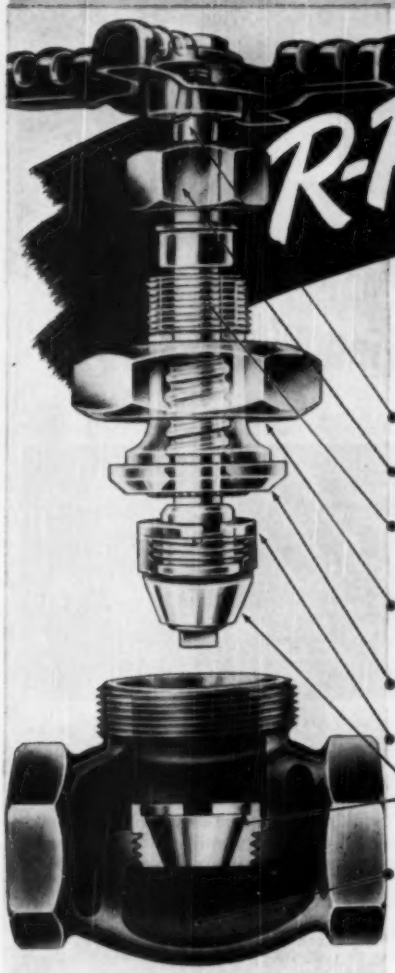
This feature and others, as important, are described in detail in Bulletin S 116 which will be sent to you on request.

T-1175

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.



R-P & C HEAVY-DUTY BRONZE GLOBE VALVE



FOR TOUGH THROTTLING CONDITIONS

500 BRINELL DISC AND SEAT

- **STEM** high tensile rolled bronze. Large diameter and long thread contact.
- **PACKING NUT** and gland follower of heavy bronze transmit even pressure onto packing.
- **STUFFING BOX** large and deep. Packed with formed rings of braided asbestos, lubricated and graphited. Can be repacked under pressure.
- **UNION NUT** heavy, rugged. Facilitates removal and replacement without danger of distorting body or threads.
- **BEVELED JOINT** permits tighter union between body and bonnet.
- **DISC LOCK-NUT** holds disc securely to end of stem.
- **FULL-PLUG DISC and SEAT RING** stainless steel of 500 Brinell—near diamond—hardness.
- **BODY** P & C High Test Bronze. Reinforcing ribs give added strength. Heavy end hexes with standard, full length threads.

Fig. 531-P
350 lbs. Steam • 1000 lbs. OWG

Send **FOR THIS FOLDER** *which contains a detailed description of this valve. Ask for* **DH-116**

ACCO

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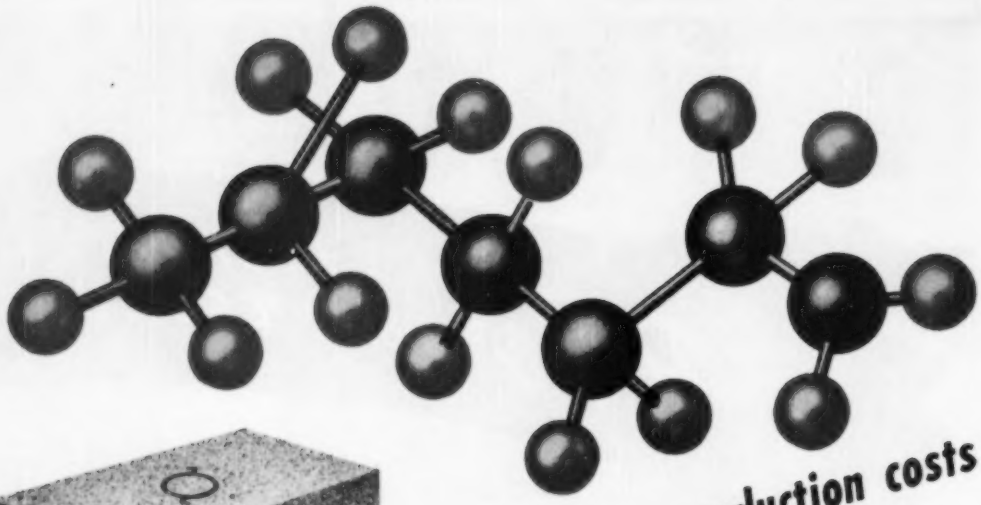
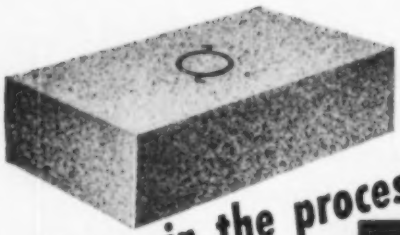
New York • Philadelphia • Pittsburgh • San Francisco • Bridgeport, Conn.

R-P & C VALVE DIVISION
AMERICAN CHAIN & CABLE

TRADE MARK

READING-PRATT & CADY VALVES





Catalysts in the process of lowering production costs

B&W INSULATING FIREBRICK + PROCESS FURNACES = Low Maintenance; Increased Production through quicker heating; Improved Quality through closer temperature control; Lower Fuel Bills = LOWER OVERALL PRODUCTION COSTS

"Reduced production costs"—this is the continuing theme of service reports from the many chemical process furnaces lined with B&W Insulating Firebrick.

Because of their low heat-storage and high insulating value, lightweight B&W IFB respond quickly to temperature changes, substantially cut heat losses. Increased production, improved quality, lower fuel bills are the direct results. And because of their superior durability in service, B&W Insulating Firebrick provide all of these advantages with extremely low maintenance cost.

Your local B&W Refractories Engineer will be glad to discuss with you the question of increasing the efficiency of your furnaces through the use of B&W IFB.

B&W

B&W REFRACTORIES PRODUCTS

B&W 80 FIREBRICK • B&W JUNIOR FIREBRICK
B&W 60 GLASS TANK BLOCKS • B&W INSULATING FIREBRICK
B&W REFRACTORY CASTABLES, PLASTICS AND MORTARS

•

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Stationary & Marine Boilers and Component Equipment
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THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 85 LIBERTY ST., NEW YORK 6, N.Y.
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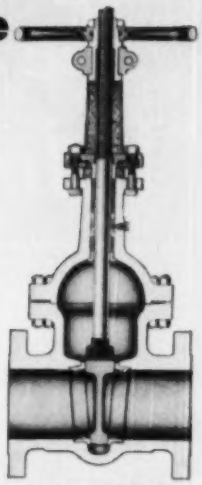
B-378

If it's piping equipment for refineries ...It's in the complete CRANE line



No. 33x, 300-Pound Steel Gate Valve for Oil and Oil Vapor Services Up to 1000° F. Max. Temp. Sizes: 1½ to 24-inch

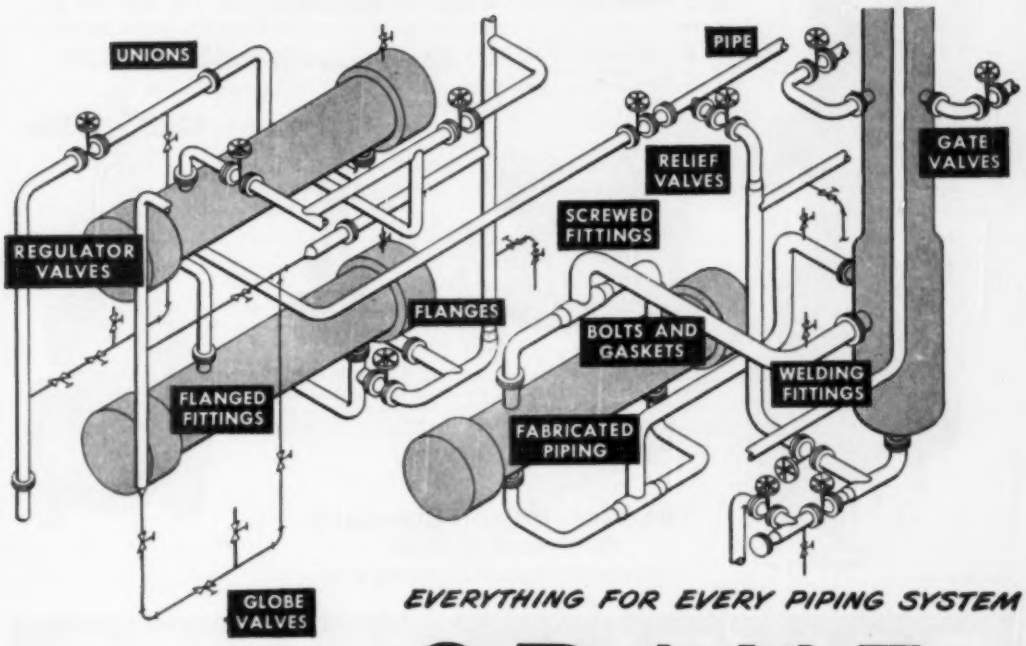
BEST FOR OIL AND OIL VAPOR SERVICES

Crane Cast Steel Wedge Gate Valves find wide application in refineries everywhere because they assure dependable performance under all conditions. Body and bonnet are unusually rugged. Straight-through ports minimize turbulence, erosion and resistance to flow. Full length disc guides insure positive seating on shoulder-type, screwed-in body seat rings.

Strong tee-head disc-stem connection, easily lubricated yoke, and ample non-corrosive bearings assure smooth operation. Made of Carbon or Alloy Steels with trim materials suitable for pressures and temperatures up to 2500 pounds at 1000° F. Flanged, screwed, or welding ends available. See your new No. 49 Crane Catalog.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

ONE ORDER TO CRANE COVERS ALL PIPING EQUIPMENT FOR THIS VAPOR RECOVERY UNIT HOOKUP, FOR EXAMPLE.



EVERYTHING FOR EVERY PIPING SYSTEM

CRANE

VALVES • FITTINGS • PIPE • PLUMBING AND HEATING

The ABC's of Powell Valve PERFORMANCE

Always the right valve. And, because Powell *can* always furnish the *right* valve, you can avoid failures that result from trying to make a valve "do" in a service to which it is not *specifically* adapted, as well as those caused by misapplication.

Built to last. Powell Valves are designed for long life at a minimum cost of maintenance. The cost of construction and materials of any Powell Valve is determined solely by the requirements of the service for which the valve is designed.

Complete Line. Powell Valves are made in all types such as Globe, Angle, "Y", Gate, Check, Non-return and Flush Bottom Tank. Materials include not only Bronze, Iron and Steel but also a wide range of Corrosion-Resistant metals and alloys.

Ask your nearest Distributor—or write direct

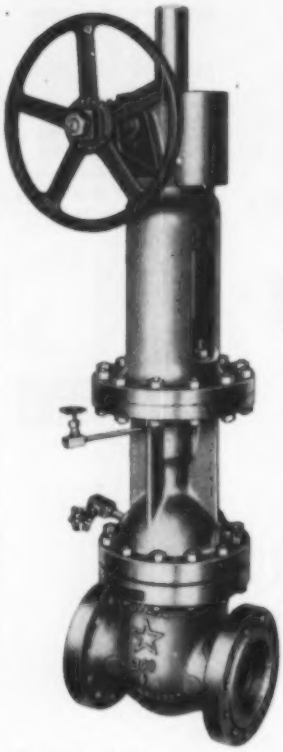


Fig. 3003 S. S. Mod.—Class 300-pound Cast Alloy Steel Gate Valve for ultra-high temperatures. Has cooling fins to reduce temperature in the stuffing box. Bevel gear operated.

Fig. 1460—Iron Body Bronze Mounted "Master Pilot" Gate Valve, with screw ends, rising stem, bolted flanged bonnet and tapered solid wedge.

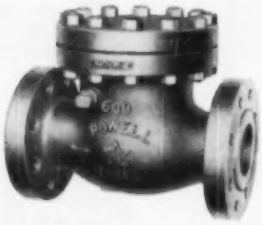


Fig. 6061—Class 600-pound Cast Steel Swing Check Valve with flanged ends and bolted cap. Disc has ample lift to permit full, straightway, unobstructed flow through valve body.

Fig. 1375—200-pound Bronze Gate Valve with screwed ends, inside screw rising stem, union bonnet and renewable, wear-resisting "Powellium" nickel-bronze seat rings and disc.

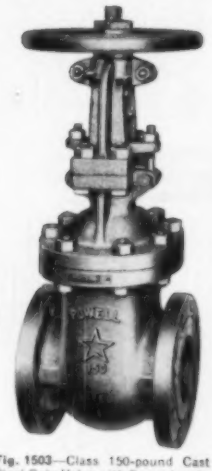


Fig. 1503—Class 150-pound Cast Steel Gate Valve with flanged ends, outside screw rising stem, bolted flanged yoke, tapered solid wedge.

The Wm. Powell Company
Cincinnati 22, Ohio
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POWELL VALVES

CHEMICO P·A VENTURI SCRUBBER

STOPS ACID FUMES

THESE PHOTOGRAPHS—taken at a pigment plant in Pennsylvania—show how effectively the Chemico P-A (Pease-Anthony) Venturi Scrubber solves the problem of waste sulfuric acid fumes. Instead of pouring from the large stack, the fumes are diverted into the Chemico unit. An infinitesimal residue is emitted through the small stack at the left of the brick chimney. The P-A Venturi Scrubber, in fact, eliminates the need for a large stack.

HERE ARE THE ACTUAL RESULTS OF THIS INSTALLATION:

Sulfuric Acid Mist Loading

INLET TO SCRUBBER	EXIT FROM SCRUBBER	EFFICIENCY
283 mg H_2SO_4 per cu ft	1.06 mg per cu ft	99.6%

The P-A Venturi Scrubber is highly effective and very economical to install and operate. It is recommended for (1) smoke abatement, (2) removal of dust and mist from gases and (3) recovery of valuable metals and chemicals.

This Chemico unit is simple and safe to operate and maintain. Any competent maintenance man can service a P-A Venturi Scrubber. No special skill is needed. Write us concerning your problem.

HOW THE P-A VENTURI SCRUBBER WORKS

Dirty gas, at high velocity, impinges upon and atomizes a curtain of liquid introduced through jets at the throat of the Venturi. Differential velocities of gas and atomized liquid result in collision of mist or dust particles with liquid droplets. The coalescence of mist or agglomeration of dust resulting from this collision makes simple cyclonic separation possible.

CHEMICAL CONSTRUCTION CORPORATION

A UNIT OF AMERICAN CYANAMID COMPANY

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EUROPEAN TECHNICAL REPRESENTATIVE
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Using Only Common Tools
CONTINUOUS OPERATION
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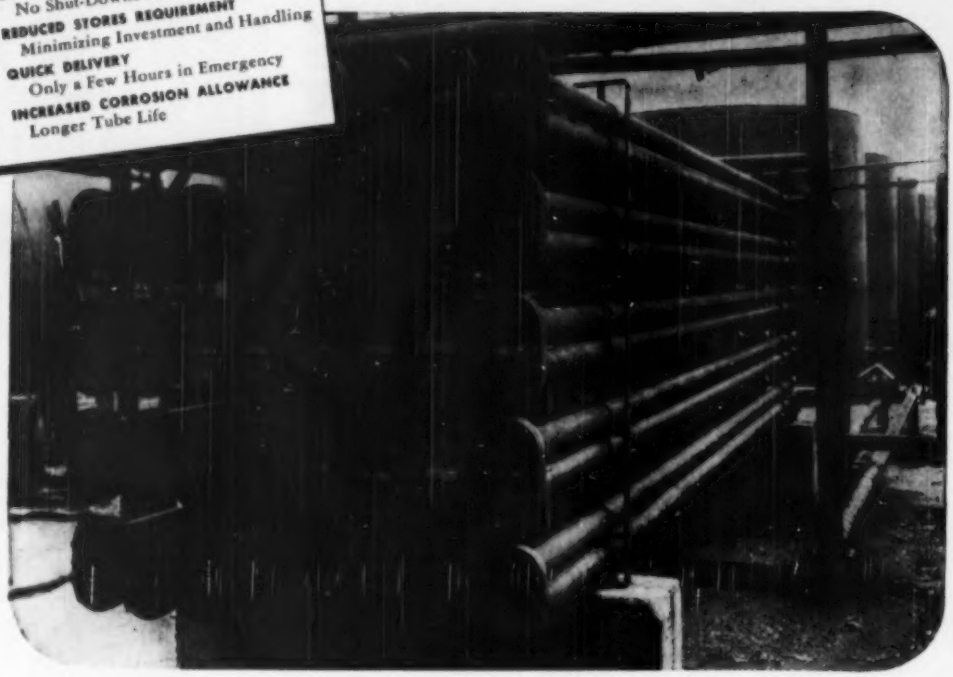
Only a Few Hours in Emergency
INCREASED CORROSION ALLOWANCE
Longer Tube Life

no obsolescence

Brown Fintube Sectional Construction Avoids Needless Waste and Expense



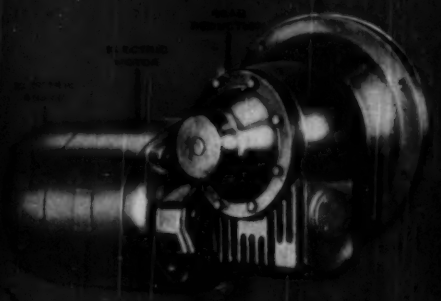
● Brown's interchangeability of parts, exacting design and precision manufacture has "licked" obsolescence.

The sections can be used in one exchanger after another — on different duties — on different products. A bank can even be broken up and the sections shipped to two or more plants, miles apart, assembled and reused. Sections not in use serve as "stores" for other sections on stream. They are *never obsoleted* by changes in duty or plant re-arrangements. You can use, and reuse them, until they are completely worn out.

For the utmost in *efficiency* and *economy*, install Brown's proven, welded fintube heat exchangers throughout your plant. Estimates and quotations furnished promptly. *Write for Bulletin No. 481.*

THE BROWN FINTUBE CO.
ELYRIA, OHIO

SECTIONAL HAIRPIN HEAT EXCHANGERS



The power drives on this machine incorporate an electric motor, a gear reduction, an electric brake and a flange mounting . . . all standard Master units that easily combine into one compact, integral power-package that's just right for this machine. This permits many parts to be stripped away from both the power unit and the completed machine . . . makes a job that's all muscle, no fat.

Master Motors, available in thousands and thousands of types and ratings (up to 150 HP) give you an enormous selection of integrally built power drives with which you too can easily secure these same results.

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Select the RIGHT power drive from Master's broad line and you can increase the saleability of your motor driven products . . . improve the economy and productivity of your plant equipment.

THE MASTER ELECTRIC COMPANY
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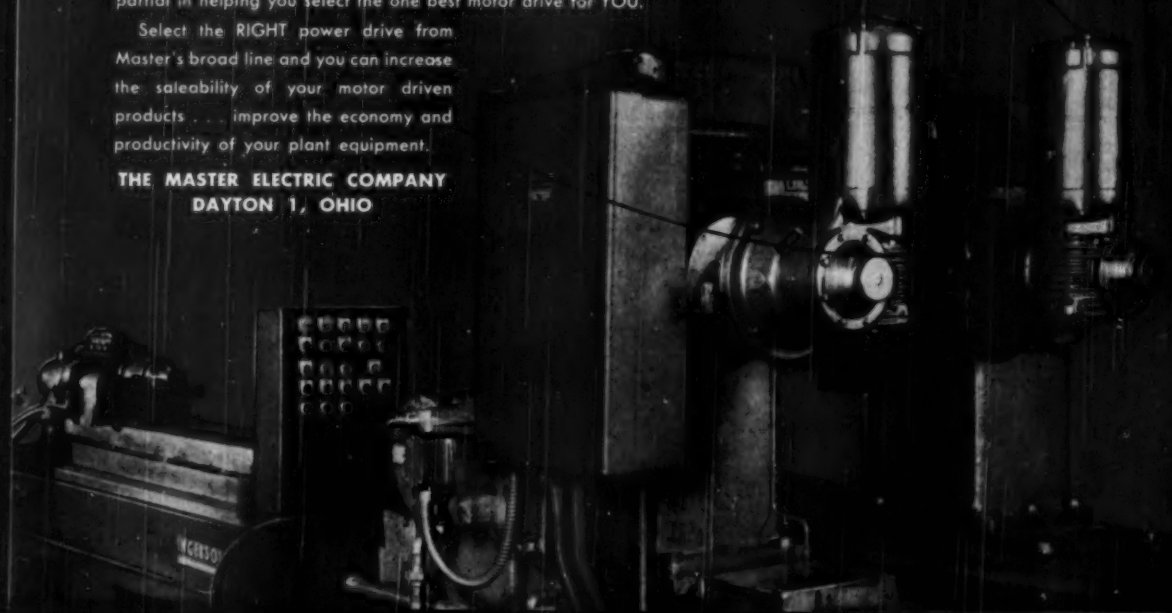
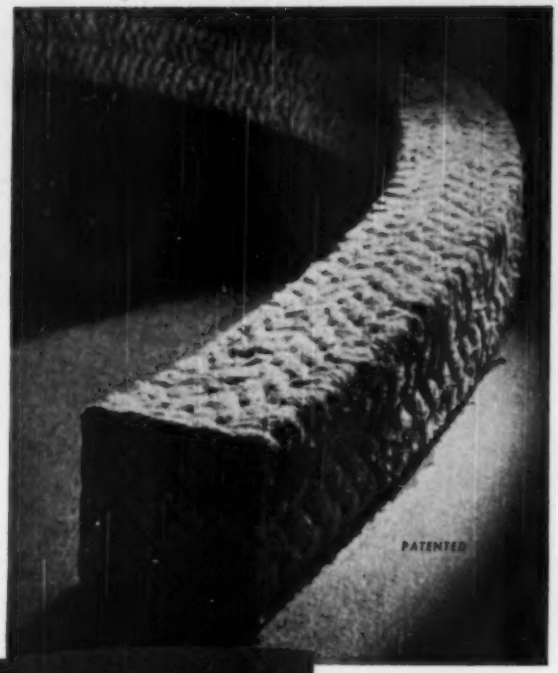


QUESTION:

Which Garlock rod packing is braided through and through for longer life?



ANSWER:

LATTICE-BRAID

The unique structural design of LATTICE-BRAID packing gives it great strength, long life and unusual flexibility.

Supplied in several styles, including:

- GARLOCK 730 (asbestos)—for hot or cold water at medium to high pressures.
- GARLOCK 731 (asbestos)—for steam, gases or water at temperatures up to 700° F.
- GARLOCK 732 (asbestos—wire inserted)—for heavy duty service against steam, oil, gases or water at temperatures up to 700° F.
- GARLOCK 733 (asbestos)—for hot or cold water or alcohol at medium or low pressures.
- GARLOCK 734 (asbestos)—for cold gasoline, kerosene and light oils.
- GARLOCK 736 (blue asbestos)—for concentrated mineral acids.
- GARLOCK 740 (flax)—for cold water at medium or low pressures.
- GARLOCK 745 (flax)—for heavy hydraulic service against cold water.
- GARLOCK 751 (cotton)—for hot or cold water.

In GARLOCK LATTICE-BRAID *every braiding strand* passes diagonally *through* the body of the packing at an angle of approximately 45°. All the strands are strongly lattice-linked together into a structural unit which holds together even when the packing is worn far beyond the limits of wear of ordinary braided packings.

Write for folder!

THE GARLOCK PACKING COMPANY
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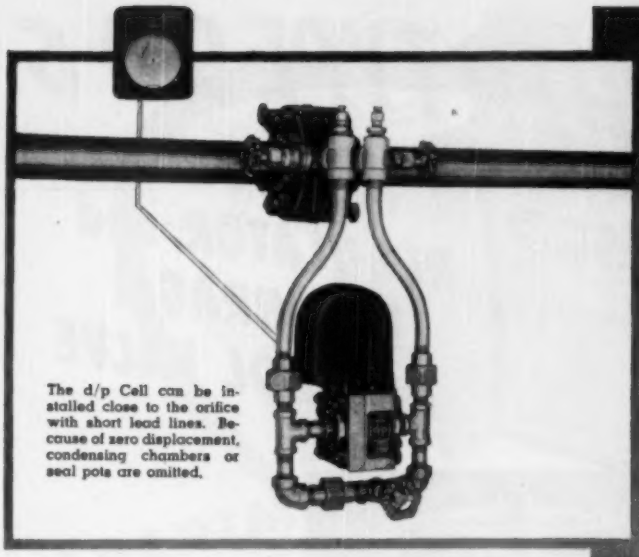
GARLOCK

PACKINGS, GASKETS AND OIL SEALS



The d/p Cell can be installed close to the orifice with short lead lines. Because of zero displacement, condensing chambers or seal pots are omitted.

Simpler Flow Measurement

in the palm of your hand

NEW • REVOLUTIONARY • MERCURY-LESS

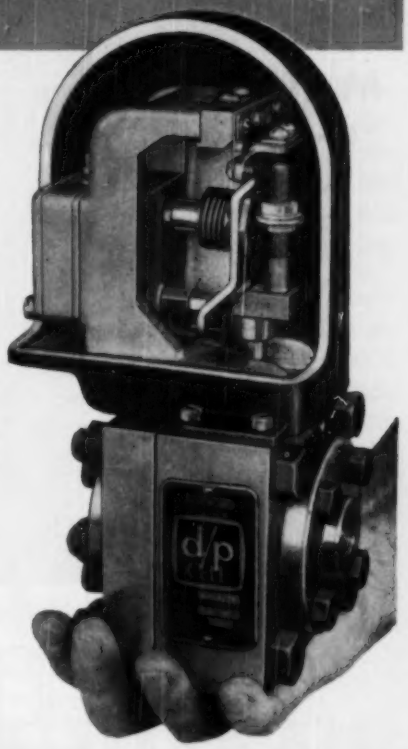
FOXBORO

DIFFERENTIAL PRESSURE CELL

Now you can simplify many troublesome flow problems . . . especially those where corrosion is a factor or the use of mercury is objectionable. This unique flow measuring device is accurate, easily calibrated, and widely applicable, and it weighs only 20 lbs. The Foxboro d/p Cell offers a combination of advantages that no other type of flow measurement can duplicate.

The Foxboro d/p Cell operates on the highly-accurate force-balance principle, transmitting flow measurement to remote, conveniently-located pneumatic receiving instruments (indicating, recording, controlling). Range: 100 in. to 800 in. H_2O. Working pressures: 500 psi and 1500 psi.

Get all the facts about this revolutionary new device for the measurement of liquid, steam, gas or air flow. Write for Bulletin 420. **The Foxboro Company, 74 Neponset Ave., Foxboro, Mass., U. S. A.**



UNIQUE ADVANTAGES

1. Type 316 Stainless Steel Construction.
2. Uses no mercury.
3. Essentially zero displacement—no need for condensing chambers on steam measurement or seal pots on liquid measurement.
4. Immediate, unfailing response to differential pressure changes.
5. Positive overrange protection.
6. Easily changed in the field to any range (100" to 800" differential).
7. Simple zero adjustment.

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SMALL . . .

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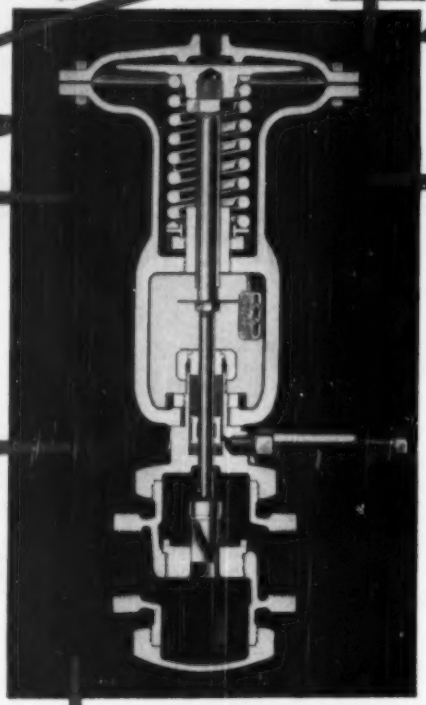
PRESSURE REGULATOR and DIAPHRAGM CONTROL VALVE



MATERIAL

Bronze and stainless steel bodies.

SIZES

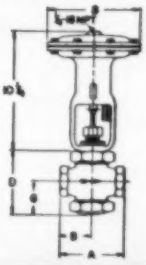
½" to 2."

SERVICE

For direct action pressure regulators and reducing valves up to 50 pounds reduced pressure.

For 2 to 15 pounds pneumatic actuation with ¾" valve travel and utilizing popular Micro-Flute Pup inner valve, V-Port, Quick-Opening or Composition Disc inner valve in single seat valves—or available with double ported V-Port or Quick-Opening inner valve construction.

Particularly adapted to service where small size and compactness are desirable.



DIMENSIONS

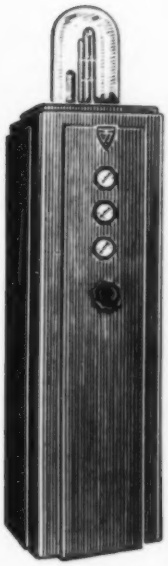
SIZE	A	B	D	G
½	3 5/8	1 13/16	3 15/16	1 15/16
¾	3 5/8	1 13/16	3 15/16	1 15/16
1	4 1/8	2 1/16	4 5/8	2 3/8
1¼	4 1/8	2 1/16	5	2 1/2
1½	4 1/8	2 3/4	5 1/2	2 7/8
2	5 1/4	2 7/8	6 1/2	3 5/16

FISHER GOVERNOR CO. Marshalltown, Iowa

APARTMENT FOR SLIME

With condenser tubes handling unchlorinated water, slime-forming bacteria never have to worry about a housing shortage. Instead, these bacteria move in, form their colonies, and the condenser tubes become apartments for slime. When this happens, the terminal log mean temperature difference rises, excess steam costs go up, and outage increases along with the labor bill for costly plug cleaning.

Chlorination, engineered by W&T and backed by 35 years' experience, has proven itself the effective answer to slime in condenser and heat exchanging equipment. It is effective because the Wallace & Tiernan De-Sliming Process attacks the cause of slime, bacteria, and "evicts" these unwanted "tenants" from their home in your equipment.



CD-32

Regardless of whether yours is an open or closed cooling system or whether you use shell and tube, trombone, or open box condensers, Wallace & Tiernan engineering plus time-tested W&T Chlorinators can put all the money-saving advantages of slime control by chlorination to work on your condensers or heat exchange equipment.

Write today for complete information.

WALLACE & TIERNAN
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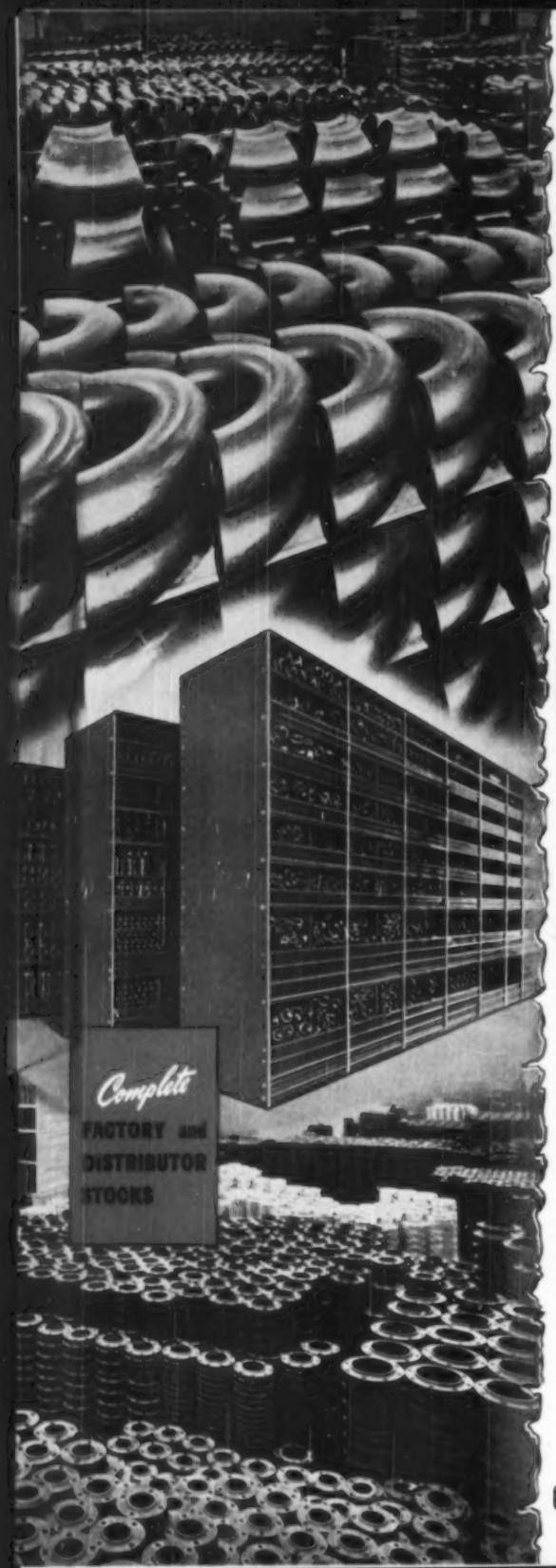
CHLORINE AND CHEMICAL CONTROL EQUIPMENT

Belleville 9, New Jersey • Represented in Principal Cities



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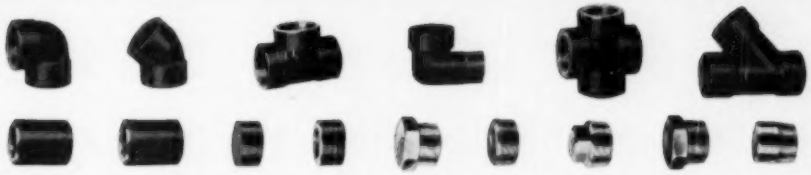
FORGED STEEL FLANGES—½ INCH THRU 30 INCHES—LARGE O.D. THRU 96 INCHES

FORGED STEEL FITTINGS—SCREWED AND SOCKET WELDING—⅛ INCH THRU 4 INCHES



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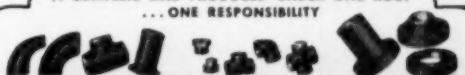
Adequate stocks in strategically located distributor warehouses . . . supplemented by extensive factory inventories of every type . . . give you double assurance of prompt service on every Ladish order. And, by standardizing on Ladish you know that every fitting is made to the unsurpassed standards of Controlled Quality for complete dependability.

of *Controlled Quality* fittings

A COMPLETE LINE PRODUCED UNDER ONE ROOF
. . . ONE RESPONSIBILITY



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ROCKWOOD
BALL TYPE
VALVES
PROVIDE
longer service life with no maintenance

Rockwood Ball type Valves continue to prove themselves superior to all other makes of valves with on-the-job performance throughout industry, day after day.

The full *round* open area of the Rockwood Valve does not permit the shape of the fluid stream to change—assures *full round flow* and minimum line pressure drop. New resilient, synthetic rubber seat in combination with the hard chromium-plated floating ball makes a tight seal—will not leak after continued use. Seating surface is protected in both open and closed positions.

Quarter turn fully opens and closes valve — operates easier and faster — improves worker efficiency.

When you replace your obsolete valves with Rockwood Ball type Valves, you'll appreciate the longer service-life with no maintenance. Available in bronze in all pipe sizes from ½" to 2" for 300 p.s.i. working pressure.

For additional information and uses, write for bulletin V-4.

Distributors in all principal cities.

7 Reasons why Rockwood Valves are your Best Buy!

1. **Full round open area - no turbulence in fluid stream.**
2. **Leak proof after continued use.**
3. **New floating ball - resists pitting, scratching and abrasion.**
4. **No exposed seating surface in open or closed position.**
5. **Easy to open or close under full pressure.**
6. **Installed in any position.**
7. **Quarter turn (90°) opening and closing valve.**

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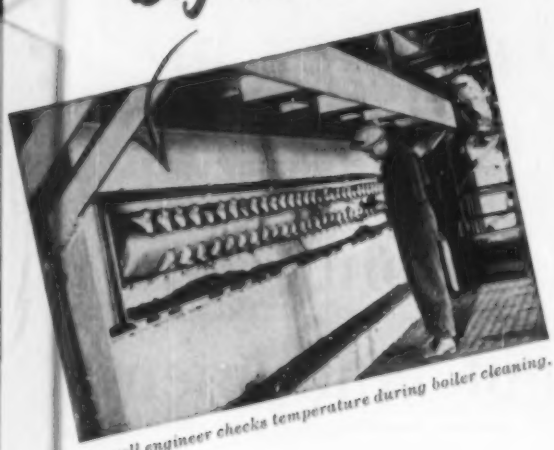
PLANT BUYERS

The **REFINERY CATALOG**

DOWELL

SERVICE SPECIALISTS IN MAINTENANCE CLEANING PROBLEMS

Big Boiler Cleaned in ONE DAY by Dowell Service!



Dowell engineer checks temperature during boiler cleaning.

Quick, Effective Maintenance Service Cuts Total Down Time in Half

A TYPICAL EXAMPLE of the economies afforded by Dowell Service is reported in the case of a midwestern refinery using five 300,000 lb. per hour boilers to generate electrical power. Before Dowell Service was used in the plant, boilers were usually down two weeks whenever repairs became necessary—during which time electricity was purchased from an outside source. Using Dowell Service to do the internal surface cleaning, the boiler is back in use in one week instead of the usual two! And the Dowell part of the operation takes just one day!

Dowell Service, using the experience of thousands of successful jobs, offers you the solution to maintenance problems of this type. It is backed by strong, continuous research programs, both in Dowell's own laboratories and in those of The Dow Chemical Company. This research provides the means for an improving service with an increasing degree of effectiveness and safety.

When you call on Dowell Service for your maintenance cleaning, experienced Dowell engineers do the job for you. They bring the special equipment—truck-mounted tanks, mixers, heaters, and proportioners—necessary for controlled cleaning. No dismantling or scaffolding is required. Liquid solvents are pumped into the equipment through regular connections. Down time is held to a minimum.

For quick, practical, economical cleaning of boilers, heat exchange equipment, water lines and water wells, call the nearest Dowell office. Free cost estimates gladly given.

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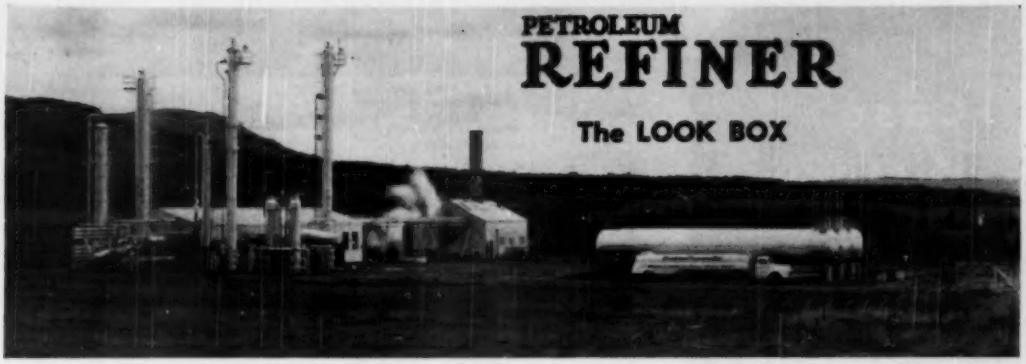


PETROLEUM REFINER

The LOOK BOX

A DANGER in the industry's current economic picture is the possible threat of an oversupply of gasoline. Recent large additions have boosted these stocks to high levels, and they are due to continue increasing for another two months. Everything else is in good condition, other stocks being at satisfactory volumes for this season of the year. Despite the tempering influence of mild weather in the country's northeast oil heating region, total distillate fuel oil inventory is being reduced to year-ago level, even though some individual plants are overstocked. Meanwhile, curtailed producing rates have resulted in such heavy drafts, crude oil stocks are low and likely to decline further during February.

The Danger of Gasoline Oversupply

The gasoline situation is not yet hopeless, but sharply reduced refinery runs are needed immediately to prevent accumulation of excessive motor fuel stocks. Otherwise, the industry's entire outlook, including that for crude oil, may be endangered. If gasoline stocks continue increasing at recent rates, the industry undoubtedly will face strong downward pressure on prices during following months. Despite its present strong character, even the crude oil price structure probably could not escape a cut if gasoline markets suffer severe reductions.

GENERAL Petroleum Corporation officials feel that expansion of its Torrance coker facilities, already the largest in the world, represents the best available answer to a problem which has been plaguing California oil refiners for the last 18 months.

Answering a State's Problem

The problem is: what to do with heavy fuel oil, now available in quantities far in excess of demand? Three factors have contributed to the problem: 1) the switching of railroads to diesel engines away from steam engines which burn heavy fuel oil; 2) the importation via pipelines of Texas natural gas which has replaced heavy fuel oil for many uses; and 3) the loss of the Orient export market for heavy fuel oil.

Since all of these three factors appear to be permanent and since the production of heavy fuel oil cannot be significantly reduced as long as demand remains high for other products with which it is mixed in crude oil, a change in processing seemed to be the only answer.

The expanded coker, which went on stream late in January, will turn about 22,000 barrels of heavy oil each day into coke (more than 800 tons), gasoline, gasoil, dry gas, and petroleum gases, the latter suitable for use as "bottled" gas.

General Petroleum engineers calculate that the new facility will bring the refinery's product yield into approximate correlation with market demand.

C. W. GEORGI of Quaker States Refining Corporation, Oil City, Pa., has written his comments on *The Look Box* item, "Better Lube Oils—When?," which appeared in the January issue of PETROLEUM REFINER. He points out factors which have influenced his company's present policies in the marketing of high-additive oils. His thoughts are well summarized in a bulletin, "Recent Developments in Heavy Duty, Detergent Oils" which his company has prepared to clarify their position in the matter. The principal conclusions are of high general interest and are in part repeated below.

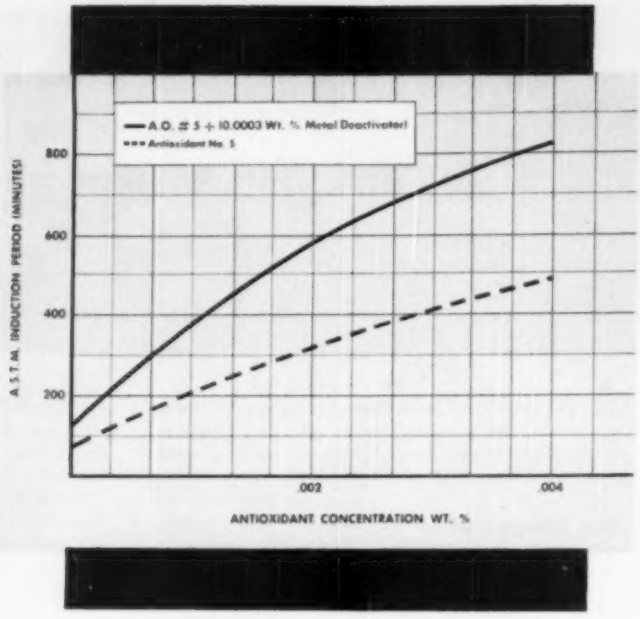
More on Better Lube Oils

The essential difference between Quaker State motor oil and Quaker State HD (heavy duty) oil is in the amount of "detergent action." Quaker State HD oil is what is generally termed a "super detergent" product, whereas Quaker State motor oil is what might be called a "mild detergent" product, in that the natural detergency characteristics of the oil itself are quite effective for general passenger car service, without resort to use of supplemental detergent additives. Both oils have the same inherent qualities of high natural viscosity index, low con-

PHOTO AT TOP OF PAGE—General view of the propane recovery plant built in Turner Valley, southern Alberta, by Western Propane, Ltd., of Calgary, Alberta. Completed and opened last fall, the plant has a daily capacity of 25,000 Imperial (28,000-30,000 U. S.) gallons.

Case History:

This chart shows improvement in induction period on thermally cracked stock containing 0.6 parts per million of copper when using Du Pont Metal Deactivator in combination with Du Pont Gasoline Antioxidant No. 5, compared with use of antioxidant alone.



Du Pont Metal Deactivator Reduces Antioxidant Treating Costs of Copper-Contaminated Fuel By 35%

Copper, if present in your gasoline in even trace quantities, may be costing you money through greater antioxidant requirements than necessary. Du Pont Metal Deactivator is the answer to such a problem because, in every case, overcoming the catalytic effect of copper is more economical with Metal Deactivator than an attempt at stabilization with antioxidants alone; and the gasoline containing Deactivator is more stable in storage.

This particular case history shows how in one refiner's copper-contaminated stock the addition of a relatively small amount of Du Pont Metal Deactivator resulted in marked antioxidant savings.

The base stock, a thermally cracked gasoline, contained 0.6 parts per million of copper. Du Pont Gasoline Antioxidant No. 5 was found to be the most effective of the three Du Pont antioxidants and a concentration of .0036 wt. % was required to obtain an induction period of 460 minutes. However, with the addition of only 0.0003 wt. % of Du Pont Metal Deactivator it was possible to obtain a 460 minute induction period with an antioxidant concentration of .0014 wt. %—a reduction in antioxidant treating costs of thirty-five per cent.

If you are not presently using Du Pont Metal Deactivator, you should check this product because copper is apt to be present when least suspected. The nearest Du Pont District Laboratory will be glad to run a Metal Deactivator test on your stocks for you. Call your Du Pont Petroleum Chemicals representative.

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sumption, stability, non-corrosiveness, etc.

The chief reason HD detergent oils are not entirely suited for passenger car engines lies in the potency of the detergent action. Since the chief cause of engine troubles from deposits comes from the fuel used, the potentiality of such trouble is directly proportional to how much fuel the engine burns. The average passenger car uses even less than 1000 gallons of fuel per year, so potential troubles with ring or valve sticking and deposits are quite limited. On the other hand, engines in commercial use operate more hours per day, at higher average loads, and burn much more fuel. The average engine in commercial service may readily burn several times as much fuel per year as the average passenger car, so that deposit troubles are accordingly that much greater a potential problem. Detergent HD oils can thus be of real benefit in truck, bus and other commercial engines, whereas this same high detergency factor is not really needed and may in fact actually be detrimental in many passenger car engines.

In most commercial fleet operations, the engines are all serviced at one point where there is good control over the oil used, the drain periods, maintenance, etc. Under this well controlled and observed maintenance, full detergent heavy duty oils function very satisfactorily and in most cases do a much better job than other types of oils. On the other hand, the average passenger car engine is very apt to be lubricated in a "hit and miss" fashion, with different brands and kinds of oils used on various occasions either for make-up or for changes. As a result, there is always good possibility of two or more kinds of oils becoming mixed in a passenger car engine and also of the engine being lubricated with one kind of oil one time and still another kind of oil at another time. Under such conditions, heavy duty detergent oils are apt to lead to trouble. If a passenger car engine should happen to develop considerable sludge deposits, due either to use of a poor grade of oil, or due to excessive accumulations of combustion chamber blow-by products from light operation at low engine temperatures, and should then suddenly have a charge of detergent heavy duty oil added, the detergent may suddenly loosen up a lot of these deposits and cause oil screen plugging, plugged oil lines, burned-out bearings, etc. It is for this reason that Quaker State motor oil has very carefully balanced "mild detergency" properties so that any previously accumulated sludge deposits which might exist in passenger car engines will not be suddenly loosened up to cause trouble.

If we could be sure that a given passenger car engine was lubricated exclusively with Quaker State heavy duty oil, we could likewise be sure that very excellent engine lubrication would result. Since this factor of mixing of different oils in passenger car engines is always with us, we accordingly have to take this condition into account and design the oil accordingly, meaning Quaker State motor oil is best for passenger cars.

The above reasoning certainly seems clear enough, and quite logical. The position of this company seems to us to be entirely correct. At the same time the concluding paragraphs do give the impression that better lubrication for passenger car engines through the use of high detergency oils may be available not too far from now and that a good part of the problem is the necessity for educating the motoring public at large. There is nothing new about the necessity for such education in lubricant usage. Lube oil men have been explaining the benefits of regular oil changes for years. Possibly even the general acceptance of the 1000-mile change interval would result in so much improvement in engine lubrication that the "super oils" would seem less attractive. Certainly some improvement is needed, however. There is now much too wide a margin between the 30,000 to 40,000-mile engine overhaul intervals which many motorists find necessary and the remarkably long periods over which engines can be satisfactorily operated with controlled lubrication procedures.

Once 8 to 2, Now 2 to 8

THE mechanical revolution in agriculture has progressed to the point that "there is now more horsepower on the farm than there is in any other industry," A. L. Solliday, executive vice president Stanolind Oil and Gas Company, Tulsa, said recently.

As the result of substituting "the machine for human sweat and animal toil," Solliday said some farm tractor operators "can take care of several hundred acres unaided except for machines," in contrast to 80 years ago when the average farm worker could cultivate only 18 acres of crops.

Describing what the advance of mechanical power means to farm production, Solliday said it now takes two farms to supply eight city families, whereas in 1900 the reverse ratio applied—"eight farms to supply two urban families."

He added that tractors on farms multiplied from practically none in 1910 to one million in 1930 and 3,375,000 today, equivalent to one tractor for every 105 acres of land under cultivation. During the past 100 years the increase in machine power enables agriculture today to produce five times more goods and services per hour of work.

Plan to Pierce 'Iron Curtain'

PRIVATE industry and a relatively obscure arm of American journalism—industrial house organs are joining in a move to help penetrate the Iron Curtain with truths about American working and living conditions.

"The nation-wide campaign to encourage and help industry employes to mail issues of their company publications to English-speaking relatives and friends in other lands was first sponsored by the Philadelphia Industrial Editors Association. George S. Talmage, editor of *The Brown Recorder*, house organ for Brown Instruments division of Minneapolis-Honeywell, and president of the Association, said "we believe that circulation among working people of other lands of these papers truly reflecting the working and living patterns of Americans can be more effective than any number of speeches by frock-coated diplomats."

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Canadian Associates: BRANDON, MANITOBA, Canadian Brown Steel Tank Co., Ltd.

DESPITE additions made since the war, the industry appears to need further expansion insofar as heating oil storage facilities are concerned. Gasoline storage capacity, on the other hand, is adequate.

These are findings of a study conducted by staffs of PETROLEUM REFINER and *World Oil*, which shows that storage capacity has not been kept in line with increased demand for some petroleum products. To assure adequate supplies in times of severe winter weather, more heating oil storage capacity is needed at all levels—primary, distributor, and consumer. More heating oil storage indirectly would also help assure adequate gasoline for peak summer demand, as clean fuel oil tanks can be converted for gasoline storage if needed.

Industry economists are generally agreed that supply is chiefly a storage problem rather than a production or a refinery yield problem. Stanley C. Hope, president of Esso Standard Oil Company, for instance, says:

"In our opinion, to attempt to meet this seasonal problem primarily by enlarged refinery capacity and adjustment of yields would be uneconomic and therefore ultimately result in high prices to the public. It is our belief that the economic approach to the problem is to plan more nearly even year-round refinery thruputs and to provide necessary storage facilities to absorb the season fluctuations in demand."

The same argument is made by Stewart P. Coleman, a Jersey Standard director, who says:

"In the long run more storage would seem to be the answer to the problem of evening out the fluctuations in industry operations caused by seasonal fluctuations in both volume and nature of demand. The investment required for storage for this purpose is but a small fraction of that for the spare capacity that must otherwise be provided in all functions of the industry if the demand swings fall directly on operations. From the standpoint of consumer relations, such storage also has the desirable effect of reducing seasonal price fluctuations, and national defense objectives are also aided by availability of greater overall storage."

Because of the changing seasonal nature of the petroleum industry the storage problem now chiefly concerns fuel oil. K. E. DeRosay, manager of fuel oil sales for Sun Oil Company, says:

"All evidence indicates that winter peak loads will become more pronounced in the future. Furthermore, the future potential increase in heating oil demand is considerably greater than the potential increase in gasoline demand."

This fact is substantiated by Dr. Courtney C. Brown, Standard Oil Company (N.J.) economist, who points out that from 1932 to 1948 demand for all petroleum products doubled, with an average yearly compounded increase of 6 percent, but that in the same period demand for light heating oils increased 10 percent, while the gain for gasoline was only 5.4 percent.

One index of storage adequacy is computed by the Bureau of Mines in its "days supply" figure. This statistic is obtained by dividing the amount of total stocks at a given date (end of the month) by the daily average current demand for the same month. The quotient is the number of days that current demand could be satisfied from current inventory.

Table 1 shows that at the beginning of the heating season last year the "days supply" was greater than at any corresponding date for the last five years.

TABLE 1
Indicated Days Supply of All Oils

	1945	1946	1947	1948	1949
January	83	85	83	76	96
February	82	87	80	78	99
March	83	92	83	79	100
April	82	89	85	82	107
May	80	88	88	87	112
June	81	91	88	87	110
July	84	94	87	90	111
August	88	96	92	92	101
September	93	102	86	97	100
October	96	99	85	99	104
November	92	95	85	98	...
December	88	85	75	92	...

From Bureau of Mines Monthly Petroleum Statements.

TABLE 2
Total Demand (Including exports)
(Bureau of Mines figures in 42 Gallon Barrels)

	Total Stocks As of Sept. 30	Total Demand for 6 Months Oct.-March Inclusive	Index Figure
Kerosine:			
1945-1946	13,675,000	55,983,000	1:4.1
1946-1947	21,251,000	64,815,000	1:3.0
1947-1948	22,276,000	73,725,000	1:3.3
1948-1949	26,062,000	67,924,000	1:2.6
1949-1950	26,650,000	.....	....
Distillate Fuels:			
1945-1946	45,059,000	152,433,000	1:3.4
1946-1947	62,019,000	178,760,000	1:2.9
1947-1948	59,764,000	218,398,000	1:3.7
1948-1949	72,385,000	215,081,000	1:3.7
1949-1950	62,212,000	.....	....

However, the index is obviously heavily overweighted by the gasoline component as inspection of the April and May figures reveal.

Fred Van Covern, API's chief statistician, factored out the fuel oil component and derives an index which tells a more significant story as far as heating oil storage is concerned.

Table 2 sets forth the Van Covern procedure. From these figures it is evident that sharply increased stocks of one product, such as a 4-million barrel step-up in kerosine for 1947-48 over the preceding year, does not guarantee a higher index number.

To figure total storage capacity in the U.S. we must distinguish at least three levels of storage (excluding the retail level except for burning oils). These levels are (1) primary storage, which is chiefly major company storage and primarily refinery storage; (2) secondary storage, which is jobber-distributor; and (3) consumer, representing the total capacity of fuel oil tanks in the homes of the nation.

The only accurate and official figures which have ever been compiled cover primary storage only, and this discussion is chiefly concerned with the primary level. Estimates of the storage available at the other levels. *Fuel Oil and Oil Heat's* figure that fuel oil distributor storage amounted to 24,244,267 barrels as of January 1, 1950. Consumer tanks average a capacity figure of 393 gallons, and Oil Heat Institute figures show currently 4,499,916 burners of No. 2 and No. 3 oil in the country. This would yield a consumer storage capacity of 41,642,000 barrels.

National Petroleum Council figures published in October, 1948, are still considered valid for purposes of analysis. Its study was made on the basis of questionnaires to 323 companies.

The significant facts brought out by this project were:

Sixty-five percent of total crude oil inventories, represents unavailable stocks. California was the highest individual district with 68 percent, and District 4 the lowest with 53 percent.

Total tankage for the storage of crude oil at refineries, tank farms, etc. totaled 416,727,000 barrels including reservoir storage in California of 2,527,000 barrels as against 177,480,000 barrels actually contained in these facilities on the date of check.

More than 30,579,000 barrels of crude are required to fill tank farm and main trunk pipe lines, and 5,165,000 as fill for crude oil carrying tankers, barges, tank cars and trucks.

That about 100 million barrels of crude are required to assure continuous operation of pipe lines and refineries and the handling and blending of the various grades of crude oils.

About one-half of all product storage is needed for continuous operation and is therefore unavailable for consumption. A large storage capacity is required to maintain normal flexibility of operations, over and above that actually occupied by current inventories. For instance, there were about 100 barrels of storage capacity for every 41 barrels of inventory.

But in no case is the difference between these inventories and capacity figures an indication of available storage space. The committee warned that

Capacity of Crude Oil, Clean Product and Residual Fuel Oil Tankage as of March 31, 1948

Note: Figures are shown in Barrels of 42 U. S. Gallons by Bureau of Mines refining districts and include all tankage available for storing Crude Oil, Clean Products and Residual Fuel Oil, as shown below, but deal only with the tankage that is located at the points (Refineries, Pipe Lines, Tank Farms and Terminals) included in the stock figures regularly reported to the Bureau of Mines on Forms 6-1311 Crude (except Producers' Lease Stocks), and Product Forms 6-1300, 6-1302 and 6-1303, East of California, and the corresponding forms in California. They do not include tankage at bulk plants, service stations, etc.

	East Coast	APPALACHIAN District I	APPALACHIAN District II	Indiana Illinois Kentucky	Oklahoma Kansas Missouri	Texas Inland	Texas Gulf	Louisiana Gulf	Arkansas-Louisiana Inland	New Mexico	Other Rocky Mountain	California	Total United States
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
CRUDE OIL TANKAGE													
1. Capacity of Tankage at Refineries	19,023,215	964,018	231,952	12,806,704	14,942,646	5,064,155	22,584,105	7,505,197	1,041,000	67,000	5,909,442	17,557,072	107,696,506
2. Capacity of Tankage along Pipe Lines and on Tank Farms	2,563,500	4,313,107	2,888,864	24,549,047	65,199,498	77,329,133	57,202,640	8,690,726	9,540,010	2,100,484	12,615,444	42,038,283	309,030,736
Total Crude Oil Tankage Capacity (1) and (2) above	21,586,715	5,277,125	3,120,816	37,355,751	80,142,144	82,393,288	79,786,745	16,195,923	10,581,010	2,167,484	18,524,886	*59,595,355	*416,727,242

NOTE: Tankage involved in Producers' (Lease) Stocks not included. * Includes 2,527,000 barrels of reservoir storage in California.

CLEAN PRODUCTS

(These include only Gasoline, Kerosine and Distillate Fuel Oil and deal only with the tankage at the locations of inventories regularly reported to the National Bureau of Mines.)

1. Capacity of Tankage at Refineries	23,603,613	2,934,432	1,225,270	34,508,373	16,892,231	5,900,793	49,271,475	11,793,981	2,021,854	195,190	7,322,425	44,132,982	199,892,619
2. Capacity of Tankage along Pipe Lines and on Tank Farms	4,720,233	533,500	537,402	9,349,365	3,117,720	1,446,007	1,817,868	1,649,260	2,072,900	.....	195,754	6,656,029	32,096,038
3. Capacity of Tankage at Bulk Terminals	46,040,451	1,591,658	1,385,745	16,327,435	4,491,030	40,000	3,195,779	3,230,418	1,589,926	1,600	150,634	9,725,702	87,770,378
Total Clean Product Tankage Capacity—(1), (2) and (3) above	74,364,297	5,059,590	3,148,417	60,275,173	24,500,981	7,386,800	54,285,122	16,673,659	5,684,680	196,790	7,668,813	60,514,713	319,759,035

RESIDUAL FUEL OIL

(This deals only with the tankage at the locations of inventories regularly reported to the National Bureau of Mines.)

1. Capacity of Tankage at Refineries	7,472,543	455,262	383,392	8,259,352	4,034,104	1,705,097	9,968,704	3,291,728	382,182	62,050	1,888,562	42,775,520	80,678,496
2. Capacity of Tankage along Pipe Lines and on Tank Farms				260,000								29,491,540	29,751,540
3. Capacity of Tankage at Bulk Terminals	7,101,872			294,277			746,823	433,915	48,600			4,324,456	12,949,943
Total Residual Fuel Oil Tankage Capacity—(1), (2), and (3) above	14,574,415	455,262	383,392	8,813,629	4,034,104	1,705,097	10,715,527	3,725,643	430,782	62,050	1,888,562	†76,591,516	†123,379,979

† Includes 41,573,510 barrels of reservoir storage in California.

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NORRIS QUALITY
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"long term operating experience indicates that anything higher than a 70 percent product-tankage relationship will begin to develop difficulties while in other installations even a considerably smaller relationship causes operating problems."

On September 1, 1949, stocks of oils of all producers, refiners, in pipe lines and in wholesalers' tanks (excluding all retail stocks) totalled 623.7 million barrels. Of this amount only 284.1 million barrels were available. Hence 339.6 million barrels were necessary as the backlog of the industry's working stocks. Such figures point up the storage problem sharply—storage capacity must be far in excess of actual inventories.

For the heating oils—the heart of the storage problem—that capacity is not currently adequate at any level, in the opinion of most industry economists. Coleman says: "Very little refinery storage has been added since before the war, whereas demand has risen some 50 percent and is of an increasingly variable nature."

President Hope of Esso Standard reports that his company has constructed an additional 1,200,000 barrels of primary storage facilities for the 1949-1950 heating season on the East Coast, and also has increased capacity of a number of bulk plants. Socony-Vacuum Oil Company in the last two years has constructed about 1.5 million barrels of additional storage throughout New England, Delaware and New York.

However, in the judgment of numerous industry experts the construction program is not keeping pace with need. Van Covern, Gray and others argue that the construction of new storage capacity should center at the primary level. At this level storage can be built for about $1.50 per barrel, but at the distributor level the cost rises to $4 to $8 a barrel, while at the consumer level it reaches $12 to $18 a barrel.

Conclusions of the current study can be summarized as follows:

● Additional heating oil storage at the primary level is needed to assure adequate supplies in case of an unusually severe winter. This job is largely the responsibility of the major oil companies which in a number of cases—but not enough—are meeting the challenge by additional construction. Total primary storage should be expanded by perhaps 15 percent to take care of anticipated increases of demand for home-heating oils over the next three years.

● The distributor level of storage (10,000 barrel tanks and under) is not adequate for anticipated future demand, but investment costs will be a strong deterrent to increasing storage at this level. The independent distributors are highly sensitive to price fluctuations, even to the extent of filling their existing storage in times of unsettled market prices.

● Consumer storage should be increased by about 30 million barrels through standard introduction of the 500-barrel tank in place of the 275-barrel tank. However, progress on this will be slow, especially in communities where larger size tanks are presently prohibited by law.

● Expansion of heating oil storage will indirectly guarantee added gasoline storage, if needed, through the convertibility of all clean-storage tankage from fuel oil to gasoline, at both the primary and secondary levels.

● Added storage facilities can best be placed closer to the consuming areas and farther away from the refineries themselves. In this respect large terminal storage facilities are the most needed type of installation at the present time.

[redacted]

1. Amount reported to B. of M. as at refineries, terminals or in pipe lines or in transit	149,993,482
2. Analysis of unavailable stocks in 1 above:	
a. Tank bottom credit 7 percent	22,262,139
b. Unavailable unfinished at refineries	8,957,265
c. In refinery lines and operating equipment.	1,523,393
d. One-half of average size water cargo receipt. Total of each individual grade calculated separately	9,993,332
e. Other unavailable stocks	14,776,096
f. Pipe line fill	4,812,521
g. Pipe line operating reserves	6,446,023
h. Unavailable in transit	6,462,372
Total unavailable clean products	75,233,131

Oil-Shale Direct Mining Cost Cut to 29.2 Cents Ton

An average of 116 tons of oil-shale per man day was mined at a direct cost of 29.2 cents per ton as compared with 56 tons at a direct cost of 49.7 cents per ton during first run in September 1948, according to Bureau of Mine Director James Boyd. Cost figures exclude depreciation and overhead. Tabulations showed direct mining cost, when the mine was operating at top level, to be 31.8 cents per ton with production averaging 108 tons per man day of total labor. At middle level operations, cost dropped to 26.5 cents and production averaged 127 tons due to change in technique from top heading operations. Improvements were shown during the latest run in mechanized equipment, drilling and blasting techniques.

API Retains Main Office, Safety Unit Transferred

The API executive committee of the board of directors has decided to retain headquarters in New York with the Department of Safety's Washington branch being moved to New York. Unit offices to remain in present locations are marketing and transportation division, Washington; production division, Dallas; and Statistics branch, Los Angeles.

The committee is also contemplating holding the board's next regular meeting April 3-4 in Houston, at which time it is expected to discuss the election of a regular president. Baird H. Markham accepted office of acting president at the API convention last November. Preparation of material has been started for the initial issue, probably in spring, of the API "Quarterly," suspended last spring.

MIT Gets Grants-in-Aid

Industrial grants-in-aid totalling $800,000 to the Massachuseetts Institute of Technology include $250,000 from Cities Service Research and Development Company of New York and $250,000 from Standard Oil Company of California. Cities Service has specified that its grant is to be applied in the fields of nuclear physics and chemistry, mechanical engineering, and chemistry and chemical engineering. The $250,000 grant of California Standard is to be applied to chemical engineering and chemistry, nuclear science and engineering, and research projects in lubrication, friction, and wear and corrosion.

Trends of Operations and Changes in Stocks

Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.

(All figures in thousands of barrels—add 000)

Trends in Week Ended	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1949:									
January 29	5,493	5,490	255,459	17,531	114,677	7,547	63,142	8,178	63,333
February 26	5,401	5,412	261,965	17,621	124,382	7,430	54,008	8,225	59,348
March 26	5,188	5,353	266,506	17,417	128,087	6,167	48,721	8,305	58,792
April 30	4,980	5,273	271,255	17,969	124,787	6,681	49,959	8,185	60,174
May 28	4,951	5,297	275,190	18,324	120,961	5,943	55,971	8,144	63,738
June 25	4,944	5,322	274,114	18,462	115,715	5,148	63,049	7,856	66,146
July 30	4,731	5,187	271,999	18,058	109,984	6,293	70,767	7,205	67,166
August 27	4,709	5,215	264,458	18,180	106,280	6,491	74,718	7,397	68,394
September 24	4,933	5,377	259,189	18,152	103,262	6,555	81,414	7,419	68,143
October 29	5,075	5,509	252,069	19,002	103,915	7,016	90,358	7,754	69,459
November 26	5,192	5,331	256,409	18,204	104,917	6,971	91,795	8,104	67,087
December 24	4,955	5,482	256,830	18,045	110,164	7,335	78,642	8,046	61,947
1950:									
January 28	4,956	5,470	*249,124	18,363	124,270	7,302	66,337	8,389	57,036

* January 21, Crude Stocks.

ALCOA ALUMINA
Catalysts and Catalyst Supports

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hydrocarbon cracking
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The controlled purity of ALCOA Aluminas helps promote better catalytic reactions and better end results. There is less possibility of contamination and side reactions. Difficulties arising from carbon deposits likewise are reduced.

ALCOA Aluminas—*Activated, Tabular and Calcined*—are regularly used as catalysts and catalyst supports for reactions such as those shown on the right. If you are interested in better yields from your catalytic reactions, let us send you further information on ALCOA Aluminas.

Samples for testing in your own plant will be furnished on request. Write to ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 617B Gulf Building, Pittsburgh 19, Pennsylvania.

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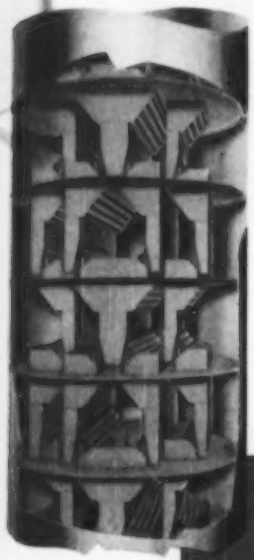
FRACTIONATING TRAYS

During the past two years, Skelly Oil Company has installed 12 towers with Koch Kaskade fractionating trays. These towers are in service as absorbers, rich oil strippers, a deethanizer, a debutanizer, a reabsorber and close-cut solvent fractior,ators. Koch Kaskade trays replaced conventional bubble trays in three of these installations.

Skelly's experience with Koch Kaskade trays has proved you, too, can save money in new installations and in replacing overloaded bubble trays. Write for our Bulletin No. 325, *no obligation.*



NOW IT'S **13**

Another installation of Koch Kaskade trays has been ordered to replace existing bubble trays.

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BROWNSVILLE PLANTS NEAR COMPLETION—This aerial photograph of the Carthage Hydrocol, Inc., Stanolind Oil and Gas Company and U. S. Industrial Chemicals Inc. projects at Brownsville, Texas, shows: 1) To the right center, the Carthage synthesis plant where natural gas will be converted to synthetic gasoline, other petroleum products and crude chemicals. The chemicals will be separated and refined in 2) the Stanolind plant, center background, and the chemicals will be prepared for market by 3) U. S. I. whose plant is shown at the left side of the picture. These plants are now in the final stages of construction.

Socony-Vacuum Adds Three Cat Crackers

Three more thermofor catalytic cracking units are planned for Socony-Vacuum Oil Company, Inc., refineries in Buffalo, N. Y.; Beaumont, Texas, and Brooklyn, N. Y. These are in addition to the four other units which the company began installing last summer in refineries at Trenton, Mich.; Augusta, Kan., and at Beaumont. Contractors have started work on several. Completion of all is scheduled during 1950. The Beaumont refinery is operated by Magnolia Petroleum Company, an affiliate.

The new TCC units, with moving-bed catalysts will replace existing Houdry fixed-bed units. They will bring an increase of 50 percent over the present 10,000-barrel-per-day capacity of each Houdry unit for a total thruput of 105,000 barrels daily.

Construction of two more of the TCC units of simplified design by the Standard Oil Company of Ohio, at its refinery in Cleveland, Ohio, has been licensed also by Socony-Vacuum.

Imperial's Winnipeg Plant Sets Spring Construction

A 10,000 barrel per day capacity is programmed for Imperial Oil Limited's $10 million refinery at Winnipeg, Manitoba, Can. and is scheduled for completion in May 1951. The contract will be let shortly and field work will begin as soon as weather conditions permit in the early spring, according to G. L. Stewart, president. Engineering design has been under way for some time.

Crude will be moved either by rail or branch pipeline from a take-off point on Interprovincial Pipe Line Company's line at Gretna, Manitoba.

Coal Research to Expand

The expansion of bench scale research and exploratory work on coal carbonization and gasification is planned by Pittsburgh Consolidation Coal Company at its Library, Pa. laboratories. The closing down in January of the pilot plant at Library, where the company and Standard Oil Development Company were engaged in joint testing fluidized solids technique for converting coal to gasoline over a 13-month period, is expected to permit the coal company to channel more funds into carbonization and gasification experiments.

Gaso Plant on Stream

Wise County's only natural gasoline plant at Chico, 45 miles northeast of Fort Worth, has been put on stream by Cities Service Oil Company, and is processing approximately 12 million cubic feet of gas daily. Capacity is expandable to 22.5 mmcf.

Built in six months, the plant has both high pressure and low pressure gathering facilities. Liquefied petroleum products and residue are going to local markets.

For Box Score Tabulation see page 83

General Petroleum Expands Many Torrance Facilities

Work is under way at General Petroleum Corporation's Torrance refinery on a $600,000 improvement project which is expected to eliminate the burning of hydrogen sulfide in the refinery gas fuel. The new installation consists of three parts; a gas collection system, an H_2S absorption plant, and a double pipe line, 8½ miles long. The project is one of the expenditures on smoke, fume, and odor control totalling in excess of $1.1 million.

Projects designed to reduce possible air pollution include: an odor-abatement system in caustic sludge processing, installed at a cost of $15,000 and now being expanded and improved at a cost of $80,000; a dust-collection system being installed on gasoline catalytic cracking units at a cost of $25,000; a "smokeless burner," installed at a cost of $140,000; a smoke absorption installation which cost $52,000; and three other improvement projects, now in the design stage, costing over $250,000 when completed.

Also at Torrance, and going on stream last month was the company's $2.3 million newly-expanded refinery coker unit which is pictured on page 128.

New Greek Refinery

Tenders have been called for in Athens for the erection of an oil refinery in Greece. The OEEC has previously agreed to the establishment of a refinery under the Greek recovery pro-

FIBER DRUM with VISQUEEN film liner. It's the answer to the oil industry's prayer! Higher tensile strength, tear resistance and chemical inertness make VISQUEEN film-lined fiber drums perfect for shipping a wide variety of petroleum products at lower cost. VISQUEEN film is unaffected by acids or alkalis, extremes of temperature.

VISQUEEN film drum liners revolutionize bulk shipping... save up to $50,000

USERS OF BOTH FIBER AND STEEL SHIPPING CONTAINERS HAIL IMPORTANT NEW DEVELOPMENTS

White-hot interest is now being centered by hundreds of manufacturers on a brand-new method of bulk shipping—a method that is absolutely without equal for product protection and shipping economies. One shipper reports 66% tare weight reduction—annual shipping charge savings of $50,000.

Developed by The VISKING Corporation engineers in cooperation with leading converters, the new method combines the virtues of VISQUEEN film with either fiber drums, cartons, or steel drums—to produce a complete shipping "package" of practically limitless possibilities.

Study the examples shown here and relate them to your own individual shipping problem. It's 100 to 1 that you'll spot a clue to spectacular savings for your firm!

LIQUIDS • SEMI-LIQUIDS • SOLIDS—ALL CAN BE SHIPPED SAFELY IN VISQUEEN FILM-LINED CONTAINERS

Running the gamut from frozen strawberries to automobile undercoating, practically any bulk product can be shipped safer and more economically in containers lined with VISQUEEN film.

Savings in handling, savings in time and money are winning more and more shippers over to the new method of shipping. A glance at the figures shown on this page will tell you why!

VISQUEEN film, the radically new liner for both steel and fiber shipping containers, is a strong, clear, odorless, tasteless polyethylene film, having an unusual combination of chemical and physical properties. Chemically inert, acids and alkalis don't affect it. Won't stick to itself or products it contacts. Extremes of temperature don't bother VISQUEEN film—even 94 degrees below zero F. left it strong and flexible. Waterproof and moisture-resistant, VISQUEEN film is particularly valuable for protecting petroleum products during shipment.

RECTANGULAR FIBER CARTONS? Sure thing! VISQUEEN film liners are available for any size of rectangular cartons, for the convenient, low-cost shipping of petroleum and other products in semi-liquid and solid form. For savings and product protection, investigate the possibilities of this revolutionary new packaging technique.

SAVINGS for steel drum shippers! VISQUEEN film liners used with steel drums are the perfect answer for shippers of "difficult" petroleum products. Insulates them from metal, prevents reaction with metal of container. Assures 100% purity when product reaches destination. Ideal for liquids or semi-liquids. Eliminates leakage.

LOOK! NO CLEANING! No matter how sticky or messy the product shipped in VISQUEEN film-lined drums—drums are instantly ready to go back into service with NO CLEANING or RECONDITIONING. Just zip out VISQUEEN film liner. Nothing sticks to interior of drum—it's clean as new! No waste—100% product recovery.

SAVINGS EFFECTED ON TYPICAL SHIPMENT FROM CALIFORNIA TO CHICAGO

Rate: $1.96 per 100 lbs.
Quantity: 150 containers per car

Former container tare per car.....7,500 lbs. or $147.00

VISQUEEN film-lined fiber drum tare per car.....2,100 lbs. or $41.16

Total saved per car.....5,400 lbs. or $105.84

WARNING!

Do Not Confuse VISQUEEN with Ordinary Polyethylene Film

All polyethylene film is not VISQUEEN. VISQUEEN film is the product of years of experience and research on the part of The VISKING Corporation, pioneers in the development of this material. Only VISQUEEN film has the benefit of this rich technical background. Always be sure to specify VISQUEEN film.

If your shipping problem is concerned with any of these fields—you can save money and time with* VISQUEEN *film-lined shipping containers.

- Light and heavy automotive lubricants
- Light and heavy aviation lubricants
- Industrial engine lubricants
- Hydraulic fluids for aviation purposes
- Railroad lubricants
- Petrolatum
- Automotive undercoating

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Firm.....
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Bethlehem heat-treated alloy-steel continuous-threaded studs for high-temperature use are stocked in required sizes at our convenient Mid-Continent and Gulf Coast store points—Houston, Odessa, Oklahoma City, Casper, and more than 30 others. They are made of AISI 4140, 4142, or 4145 steel to ASTM Specification A193 (latest revision), Grade B7, 1100 F minimum tempering temperature, ***and are threaded to ASA B1.4, Class 7 thread fit***. These studs also conform to the physical, chemical, and thread requirements of the discontinued ASTM Specification A96, Class C.

Also stocked are Bethlehem Quenched Nuts, which are high enough in tensile strength to break any stud on which they are used. Studs can also be supplied with Bethlehem Treated Nuts. These two classes meet, respectively, ASTM A194 specifications for Grade 2H and Grade 2 nuts. ***Studs and nuts are marked with the ASTM grade symbol to permit ready identification.***

We can also manufacture large-size or extra-length Grade B7 studs for special requirements. These can be shipped promptly from our local plants.

Also available for factory shipment are ASTM Specification A261 (latest revision) Grade BO carbon-steel studs for moderate service conditions, and ASTM Specification A193, Grade B14 alloy-steel studs for more severe conditions.

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BETHLEHEM STEEL

HEADQUARTERS for REFINERY SUPPLIES

gram. Plans call for a refinery which can process 10,000 barrels of crude oil daily and produce percentages of refiner products as follows: motor gasoline, 26.25 percent; white spirit, 0.25; kerosine, 5.00; diesel oil, 22.5; fuel oil, 33.50. It is expected that Middle East crude will be used.

The refinery will include topping, thermal cracking and reforming plants, with provisions also for the production of lead tetraethyl for the increase of the octane number of gasoline products.

Phillips Okmulgee Plant

Immediate construction on a new oil separating and processing plant at Okmulgee, Okla., is planned by Phillips Petroleum Company with completion scheduled next summer. The present plant, to be put on a full-time basis, is making motor gasoline, diesel fuel, kerosine, fuel oil, and heating distillates. The lubricating division was shut down last year at the same time a lubricating oil manufacturing plant was completed in Kansas City. (Page 108, Refiner for June, 1949.)

Port Jerome Enters Second Stage of Reconstruction

The first stage of the postwar program for the Port Jerome refinery of Standard Francaises des Petroles has been largely completed with the second stage, embracing cat cracking facilities, to extend over several years. The first stage, begun in 1944, consisted of reconstruction and operation at maximum thruput as possible in line with the general aims of the French government and the necessity of meeting immediate product demands. The plant has a present capacity of 40,000 barrels daily, but is now running about 35,000 barrels daily. Prewar crude-oil capacity was about 25,000 barrels daily.

The postwar processing scheme was built around Venezuelan crude oil for lube and asphalt production. Middle East oil also will be processed for gasolines, burning oil and other fuels.

At Port Jerome, future expansion includes, besides second stage plans for cracking facilities, either thermal or catalytic, the construction of propane dewaxing and deasphalting. Work on these units will start shortly.

Under reconstruction, most of the gas plant has been rebuilt, the lube rerun still reinstalled and the lube facilities modernized. The phenol-treating plant has been repaired and improved, and a completely new asphalt oxidizing plant constructed. The boiler house was rebuilt, the tankage repaired, and the mechanical facilities at the refinery improved.

Buys Alabama Refinery

Full production by April 1 is scheduled for Coastal Petroleum Refinery's facilities at Blakely Island, near Mobile, Ala., shut down since last year. The company and the Alabama refinery were recently acquired by American Bitumuls Company, a subsidiary of Standard Oil Company of California. Conversion and enlargement is planned for making all grades of paving asphalts and bitumuls.

Aim of the purchase was to give full service to the southern market for paving materials and types of industrial asphalts, according to C. W. Stewart, president of the bitumuls firm.

TABULATION OF REFINERY AND OTHER PLANT CONSTRUCTION

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
EAST									
California Refg. Co.	Perth Amboy, N.J.	Houdriflow Cat. Crk.	25,000	.....	Engineering	.....	Houdry	Houdry, Braun	Braun
E. I. Dupont	Parkersburg, W. Va.	Tetrafluoroethylene Resin Plant	.....	.....	Under Constr.	Summer, 1950	.....	.....	.....
*Esso Standard Oil Co.	Richmond, Va.	Esostane Bottling Plt.	3,500 gals.	$70,000	Under Constr.	April 13, 1950	.....	Staff	Howard-Mitchell
Esso Standard Oil	Bayonne, N.J.	MEK Dewaxing	7,500 bbls.	.....	Under Constr.	Jan., 1950	Texaco	Badger	Badger
Esso Standard Oil	Bayonne, N.J.	Steam Boilers	400,000 lbs. hr.	.....	Under Constr.	2nd Qtr., 1950	.....	S.O.D., Day & Zimmerman	S.O.D. & Zimmerman
Freedom-Valvolene Oil Co.	Freedom, Pa.	Filter Plant	800 bbls	.....	Completed	.....	.....	.....	.....
Freeport Sulphur Co.	Westville, N.J.	Sulfur Recovery	40 tons	.....	Contracted	.....	.....	.....	Girdler
The Pure Oil Co.	Savannah, Ga.	Lube Bld, Pkg.	.....	.....	Under Constr.	Jan., 1950	.....	.....	.....
Quaker State Oil Refining Corp.	Emlenton, Pa.	Boiler Plant Add.	65,000 lbs. hr.	$160,000	Completed	.....	.....	.....	Staff
Socony-VacuumOilCo.	Paulsboro, N.J.	Propane Deasph.	5,950 bbls.	.....	Under Constr.	.....	Juik	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	MEK Dewaxing	3,300 bbls.	.....	Under Constr.	1st Qtr., 1950	Texaco	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	Light Oil Trtng.	28,000 bbls.	.....	Designing	.....	.....	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	Mod. Comp. Pkg. Dept.	5,000 bbls.	.....	Under Constr.	Jan., 1950	.....	Staff	Staff
L. Sonneborn Sons.	Petrolia, Pa.	Antipollution	.....	$400,000	Under Constr.	1st Qtr., 1950	.....	Chemico	Knowles
United Refining Co.	Warren, Pa.	Lab. Steam Gen.	60,000 lbs. hr.	.....	.....	4th Qtr., 1950	.....	.....	Union Iron Wks.
MID-CONTINENT									
Cities, Service, Del.	Cicero, Ill.	Compound Plt.	1,200 bbls.	$4 million	Contracted	July, 1950	.....	.....	Sollitt
Columbian Fuel Corp.	Hickok, Kans.	Desulfurination	2,000 mcf	$15,000	Under Constr.	.....	.....	Graff	Graff
Consolidated Gas Utilities Corp.	Cement, Okla.	Compr. Sta.	40,000 mcf	.....	Under Constr.	Jan., 1950	.....	Dresser	Dresser
Deep Rock Oil Corp.	Cushing, Okla.	Cat. Cracker	5,000 bbls.	.....	Under Constr.	Spring, 1950	.....	U.O.P.	J. & L. Constr.
The Derby Oil Co.	Wichita, Kans.	Cat. Crk. Change	.....	.....	Planning	.....	.....	.....	.....
Dewese Oil Co.	Weston, Ohio	Lube Filtering	250 bbls.	$15,000	Under Constr.	Spring, 1950	.....	Staff	Staff
The Dow Chem Co.	Midland, Mich.	Comp. Sta. & Pipeline	5,000 mcf gas	$1.5 million	Under Constr.	Jan., 1950	.....	Staff	Prichard, Mahoney
Globe Oil & Ref. Co.	Lemont, Ill.	Cat. Cracker	6,000 bbls.	$1 million	Completed	.....	U.O.P.	U.O.P.	.....
Gulf Oil Corp.	Kiefer, Okla.	Gasn. Plant	14,500 mcf	.....	Under Constr.	.....	.....	.....	.....
Indiana Farm Bureau Cooperative Assn.	Mt. Vernon, Ind.	Fluid Cat. Cracking Unit	4,000 bbls.	.....	Under Constr.	1951	.....	U.O.P.	Staff
Lever Bros. Co.	Hammond, Ind.	Hygirtol Plant	150,000 ntf	.....	Under Constr.	Jan., 1950	.....	Staff	Girdler
Magnolia Pet. Co.	Grant County, Kans. (Hickok)	Gasoline Plant	100,000 mcf	.....	Under Constr.	Jan., 1950	.....	Staff, Waleo	Waleo
Magnolia Pet.	Chitwood, Okla.	Pressure Maint. & Cycling	24,750 mcf	.....	Under Constr.	.....	.....	Staff, Constr. Service	Constr. Service
Magnolia Pet.	Stephens County, Okla.	Gasoline Plant	30,000 mcf	.....	Under Constr.	Jan., 1950	.....	Staff, J. & L. Constr.	J. & L. Constr.
Midland Cooperative Wholesale	Cushing, Okla.	Cat. Poly Unit	200 bbls.	.....	Authorized	Early 1950	.....	.....	Ref. Eng. U.O.P.
Mississippi River Fuel Co.	Star City, Ark.	Comp. Sta.	5,000 hp.	.....	Under Constr.	Feb., 1950	.....	Ref. Maint.	Ref. Maint.
Mississippi River	Pocahontas, Ark.	Comp. Sta.	5,000 hp.	.....	Under Constr.	Feb., 1950	.....	Ref. Maint.	Ref. Maint.
Mississippi River	Frederickstown, Ark.	Comp. Sta.	4,000 hp.	.....	Under Constr.	Feb., 1950	.....	Ref. Maint.	Ref. Maint.
National Co-Op. Refinery Assn.	McPherson, Kans.	Polymerization	450 bbls.	$430,000	Planning	.....	U.O.P.	.....	.....
Northern Nat. Gas Co.	Clifton, Kans.	Compress. Add.	1,600 hp.	.....	Completed	.....	.....	.....	Fluor
Northern Nat. Gas	Mullinville, Kans.	Inc. Comp. Cap.	3,200 hp.	.....	Completed	.....	.....	.....	Dresser
Northern Nat. Gas	Sublette, Kans.	Gasoline Plant	265,000 mcf	.....	Authorized	Mar. 1, 1950	.....	.....	Pritchard
Northern Nat. Gas	Sublette, Kans.	Increase Comp.	3,200 hp.	.....	Completed	.....	.....	.....	Fluor
Northwestern Refining Co.	St. Paul Park, Minn.	Loading Rack, Products Transfers Line	500,000 gals.	$40,000	Completed	.....	.....	Staff	Staff
The Ohio Oil Co.	Muncie, Ind.	Ref. Products Term.	100,000 gals.	.....	Under Constr.	.....	.....	Staff	Michael-Peling
Oklahoma Refg. Co.	Seminole, Okla.	Refinery	200 bbls	$40,000	.....	.....	.....	.....	.....
Osceola Refining Co., Inc.	Reed City, Mich.	Desalting Unit	2,000 bbls.	$10,000	Authorized	1st Qtr., 1950	Petreco	Petreco	Staff

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Pan-Am Southern Corp.	El Dorado, Ark.	Delayed Coke Water Cooling Tower, Steam Gen. Boiler, Coke & Loading	9,300 bbls.	.....	Planning	Sept., 1950	.....	Lummus	Lummus
Petro Corp.	Blue Island, Ill.	Houdry, Cat. Crk., LPG Recov.	5,000 bbls.	$400,000	Under Constr.	.....	Houdry	Houdry	Clarke
Petroleum Specialties, Inc.	Flat Rock, Mich.	Cat. Cracker	3,000 bbls.	$2 million	Planning	.....	.....	.....	.....
Phillips Pet. Co.	Kansas City, Ks.	Cat. Cracker	24,000 bbls.	$10 million	Under Constr.	Jan., 1950	.....	Braun	Braun
*Phillips Petroleum	Okmulgee, Okla.	Oil Separating Process Plt.	.....	.....	Under Constr.	3rd Qtr., 1950	.....	.....	.....
Phillips Pet., et al	Edmond, Okla.	Add Nat. Gaso Plant	60,000 mcf	.....	Under Constr.	April, 1950	.....	.....	Ref. Maint.
The Pure Oil Co.	Toledo, Ohio	Revamp. Crd. Reform.	.....	.....	Completed	.....	.....	.....	Cat. Constr.
The Shallow Water Refining Co.	Shallow Water, Kansas	Reforming Unit	1,250 bbls.	$85,000	Under Constr.	April, 1950	Perco	Koch Eng.	Koch Eng.
*Shell Oil Co.	Elk City, Okla.	Nat. Gaso. Plt	100 mcf gas.	$6 million	Planning	.....	.....	.....	.....
Shelly Oil Co.	El Dorado, Kans.	Crd. Dist. Cat. Crk.	†35,000 bbls.	$8–10 million	Under Constr.	Mid 1950	.....	.....	.....
Socony-Vacuum Oil Co.	E. St. Louis, Ill.	Thermal Crack.	13,200 bbls.	.....	Under Constr.	Jan., 1950	.....	Staff	Bechtel
Socony-Vacuum	E. St. Louis, Ill.	Miscel Ref. Adds.	.....	.....	Under Constr.	Jan., 1950	.....	Staff, Bechtel	Bechtel
Socony-Vacuum	E. St. Louis, Ill.	Delayed Coking	8,700 bbls.	.....	Under Constr.	March, 1950	.....	Staff, Bechtel	Bechtel
Socony-Vacuum	Augusta, Kans.	Houdry Conversion to T.C.C.	15,000 bbls.	.....	Planned	Mid. 1950	Socony-Vacuum	.....	.....
Socony-Vacuum	Trenton, Mich.	Houdry Conversion to T.C.C.	15,000 bbls.	.....	Planned	Mid. 1950	Socony-Vacuum	.....	.....
Standard Oil Co., (Indiana)	Whiting, Ind.	Outside Battery Limit Facilities	.....	.....	Under Constr.	.....	.....	Fluor	Fluor
Standard Oil Co., (Ohio)	Cleveland, Ohio	Houdry Cat. Change	.....	$375,000	Under Constr.	Jan., 1950	.....	.....	Cat. Constr.
Standard (Ohio)	Cleveland, Ohio	Cat. Crk. Expansion	8,000 bbls.	$4 million	Planning	Nov., 1950	Socony-Vacuum	Bechtel	Bechtel
*Standard (Ohio)	Cleveland, Ohio	Houdry Conversion to TCC	18,000 bbls.	$6 million	Planning	Jan., 1951	Socony-Vac.	Bechtel	Bechtel
*Standard (Ohio)	Lima, Ohio	Clay Contact	2,400 bbls.	$1 million	Under Constr.	Mid., 1950	.....	Lummus	Lummus
Standard (Ohio)	Lima, Ohio	Inc. Tank. Cap.	215,000 bbls.	$240,000	Under Constr	Feb., 1950	.....	Staff	Hammond
Standard (Ohio)	Lima, Ohio	Liquid Gas Plt.	2,000 bbls.	$220,000	Under Constr.	Feb 1, 1950	.....	Staff	Undetermined
Standard (Ohio)	Lima, Ohio	Furfural Unit	4,500 bbls.	$13 million	Contracted	1951	Texaco	Lummus	Lummus
Standard (Ohio)	Lima, Ohio	Crd. Dist. Coke	19,500 bbls.	$5.5 million	Under Constr.	Feb., 1950	Kellogg	Kellogg	Kellogg
Standard (Ohio)	Lima, Ohio	Solvent Dewax.	3,500 bbls.	$4.5 million	Under Constr.	Mid. 1950	Texaco	Lummus	Lummus
Standard (Ohio)	Lima, Ohio	Vacuum Unit	9,000 bbls.	$1 million	Under Constr.	Mid. 1950	.....	Lummus	Lummus
Standard (Ohio)	Lima, Ohio	Propane, Deasph.	800 bbls.	$1 million	Under Constr.	Mid. 1950	.....	Kellogg	Kellogg
Sun Oil Co.	Toledo, Ohio	Cat. Crack., Crude Dist., Vac., Poly	30,000 bbls.	$20 million	Under Constr.	March, 1950	Houdry	Houdry, Cat. Constr., Process Eng., Staff	Cat. Constr.
Sun Oil	Toledo, Ohio	Compressor Sta.	3,840 hp.	.....	Under Constr.	Feb., 1950	.....	Fluor	.....
The Texas Co.	Lawrenceville, Ill.	Expand Refinery	†20,000 bbls.	.....	Under Constr.	April 1, 1951	.....	Foster Wheeler, Kellogg	Foster Wheeler, Kellogg
Tide Water Associated Oil Co.	Drumright, Okla.	Houdriflow Unit Cat. Cracker	4,500 bbls.	.....	Under Constr.	Mar., 1950	Houdry	.....	Process Eng.
U.S. Dept. of Interior	Louisiana, Mo.	Demonstration oil-from-coal	80 bbls.	$5 million	Under Constr.	Feb., 1950	.....	Koppers	Koppers
Vickers Petroleum Co., Inc.	Potwin, Kans.	Thermal Poly Unit	250 bbls.	$100,000	Authorized	Feb., 1950	U.O.P.	Ref. Eng.	Ref. Eng.
Wood River Oil & Refining Co., Inc.	Hartford, Ill.	Fluid Cat. Cracker	7,500 bbls.	$2.5 million	Under Constr.	Jan., 1950	U.O.P	Koch	Staff
SOUTHWEST									
Ada Oil Co.	Houston, Texas	Loading Sta.	.....	.....	Under Constr.	.....	.....	Belco	.....
Alba Refg. Co.	Alba, Texas	Asphalt Refining	2,000 bbls.	$150,000	Under Constr.	Feb. 15, 1950	.....	.....	.....
Calumet Refg. Co.	Princeton, La	Blending Oil Tank House	700 bbls.	.....	Under Constr.	1st Qtr., 1950	.....	Staff	Staff
Carthage Hydrocol, Inc.	Brownsville, Texas	Hydrocol	87,000 mcf	$28 million	Under Constr.	Feb., 1950	Hydro-Res., Inc Texaco	McKee, Hydro-Res., Inc.	McKee
Cities Service Oil	Chico Field, Tex.	Natl. Gaso. Plt.	22,000 mcf	.....	Completed	.....	.....	Fluor	Fluor
Cities Service Oil	St. Rose, La.	Lube Oil Blending	4,000 bbls.	$750,000	Under Constr.	Feb., 1950	.....	Day & Zimmerman	Day & Zimmerman
Coastal Refineries, Inc. & Mayfair Minerals, Inc.	McAllen, Texas	Cycling Plant	75,000 mcf	.....	Under Constr.	Mar., 1950	.....	Gaso. Plant	Gaso. Plant
Continental Oil Co.	McAllen, Texas	Add Gaso. Plt.	20,000 mcf	$1.5 million	Under Constr.	Feb., 1950	.....	.....	J. & L. Constr.
Continental Assocs.	Near Nordheim, DeWitt County, Texas	Gas Comp.	12,000 mcf	$1 million	Under Constr.	Jan., 1950	None	Process Eng.	Process Eng.
Del Rey Petroleum Co.	Chesterville, Tex.	Pressure Absorption Plant	25,000 mcf	.....	Under Constr.	.....	.....	O. L. Olson	Ole Olson
Department of the Army	Houston, Texas	Anhydrous Ammonia Facility	2,100 tons monthly	$3.5 million	Completed	.....	.....	Girdler Corp.	Hercules Powder Co.
Dow Chemical Co.	Freeport, Texas	Ammonia Plant	100 tons	$5 million	Planning	Late 1950	.....	.....	.....
Dow Chemical	Freeport, Texas	Chlorine Addition	.....	.....	Under Constr.	.....	.....	Staff	Tellepsen
El Paso Natural Gas Co.	Mohane Field, Texas	Gasoline Plant	16,700 mcf	.....	Completed	.....	.....	Fluor	Fluor
El Paso Natural Gas.	Mohane Field	Treating Plant	.....	.....	Completed	.....	.....	Fluor	Fluor
El Paso Natural Gas.	Moore County, Texas	Compressors	10,500 hp.	$1.8 million	Completed	.....	.....	Staff	.....
El Paso Natural Gas.	Moore County, Texas	Gas Dehydration Adds.	130,000 mcf	$55,000	Completed	.....	.....	Stearns Roger	Staff
El Paso Natural Gas.	Castro County, Texas	Compressor Sta.	4,050 hp.	$1.1 million	Under Constr.	Mar., 1950	.....	Staff	Staff
El Paso Natural Gas.	Crane County, Texas	Compressor Sta.	4,400 hp.	$1.27 million	Under Constr.	June, 1950	.....	Staff	Staff
El Paso Natural Gas.	Ector County, Texas	Compr. Unit	3,200 hp.	$550,000	Under Constr.	Feb., 1950	.....	Staff	Staff
E. I. DuPont de Nemours Co., Inc.	Victoria, Texas	Chemical Intermediate for Nylon	.....	.....	Design	Early 1951	.....	Staff	Staff
Esso Standard Oil Co.	Baton Rouge, La.	MainOffice,Cafeterias, Crude Desalting Unit	.....	.....	.....	May, 1950	.....	Bodman & Murell, Staff	Staff
Evangline Refining Co.	Jennings, La.	Perco Cycloversion	600 bbls.	.....	Completed ‡	.....	.....	Grebe & Doremus	Mason
Humble Oil & R Co.	Katy, Texas	Add Propane, Absorp., Refrig.	Unchanged	.....	Completed	.....	.....	Stearns-Roger	Stearns-Roger
Humble Oil & R	Baytown, Texas	Roof Replacing of Butyl Bldg.	.....	.....	Under Constr.	Feb., 1950	.....	Staff	Tellepsen

• CONTINUED ON PAGE 87

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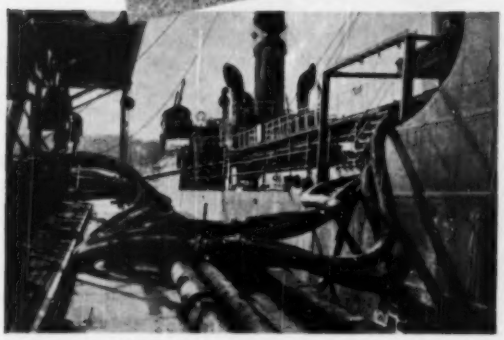

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REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Humble O&R.	Baytown, Texas	Miscl. Facilities	.....	$1 million	Projected	.....	.....	.....	.....
Humble O&R.	Jourdanton Field, Texas	Gasoline Plant	26,000 mcf	.....	Under Constr.	Early 1950	.....	.....	Hudson
Humble O&R.	Baytown, Texas	Research Bldg.	.....	.....	Under Constr.	Aug., 1950	.....	Voorhees-Walker	Knutson
Humble O&R.	Baytown, Texas	Mech. Maint. Bldg.	.....	.....	Under Constr.	Oct., 1950	.....	Ferguson	Bellows
Magnolia Pet. Co.	Beaumont, Tex.	Two Houdry's to T.C.C.	20,000 bbls.	.....	Authorized	Late 1950	.....	.....	Lummus
Magnolia Pet.	Seeligson Field, Premont, Texas	Gasoline Cycling	150,000 mcf Cycled	.....	Under Constr.	.....	.....	Hudson	Hudson
Magnolia Pet. (Operator) et al.	Lolita-La Ward, Jackson County Texas	Comp. Sta.	15,000 mcf	.....	Under Constr.	Feb., 1950	.....	West	West
Mathieson Chem Co.	Pasadena, Texas	Fertilizer Plt.	.....	.....	Under Constr.	1950	.....	Owner	.....
Mayfair Minerals	McAllen, Texas	Cycling Plant	50,000 mcf	.....	Under Constr.	Mar., 1950	.....	Gasc. Plant	Gasc. Plant
McMurray Refining Co.	Tyler, Texas	Fluid Cat Cracker, Gas-Concentration, Feed Prep. & Cycle-Oil Crack.	5,000 bbls.	.....	Planned	Fall, 1950	.....	U.O.P.	U.O.P.
Midland Gasoline Co.	Conroe, Texas	Enlarge Gasoline	100,000 gals.	.....	Completed	.....	.....	Gasc. Plant	Gasc. Plant
*North American Oil Consolidated & Unger & Frazier.	Bartlett Field, Jones County,	Gasc. Plt., Gas Injection Facilities.	.....	.....	Planning	.....	.....	.....	.....
Northern Nat. Gas Co.	White Deer, Texas	2 Comp. Stas.	60 hp., 900 hp.	.....	Completed	.....	.....	Staff	Dresser
Pan Am. Ref.	Texas City, Tex.	Desulfo Unit	.....	$25,000	Under Constr.	Early 1950	.....	Tellepsen	Tellepsen
Pan Am. Ref.	Texas City, Tex.	Lab., Pilot Plt. Additions	.....	.....	Under Constr.	Spring, 1950	.....	Ferguson	Ferguson
Panhandle Producing & Refining Co.	Wichita Falls, Texas	Cat. Cracker	1,500 bbls.	$1 million	Under Constr.	Jan., 1950	U.O.P.	U.O.P., J. & L.	J. & L. Constr.
Phillips Chemical Co.,	Etter, Texas	Prod. of Nitric Acid	225 tons	.....	Completed	.....	DuPont	Chemico	Brown & Root
Phillips Chemical	Etter, Texas	Fertilizer Plant	300 tons	.....	Under Constr.	Mar., 1950	Chemico	Chemico	Brown & Root
Phillips Chemical	Borger, Texas	Increase Cap. Phil-black Carbon Black Plt.	8 mln. lbs. yr.	.....	Completed	.....	.....	Staff	.....
Phillips Chemical	Etter, Texas	Inc. Cap. Cactus Ammonia Plant	440 tons	$5.3 million	Under Constr.	Mar., 1950	Chemico	Chemico	Brown & Root
Plymouth Oil Co.	Rankin, Texas	Gas Compression, Absorp.	70,000 mcf	$5.5 million	Under Constr.	1950	.....	.....	Hudson
*Pontiac Refining Co. & Chicago Corp.	Corpus Christi, Texas	Refinery, Petrochem. Plt.	180,000 bbls.	$15 million	Design, Planning	Mid., 1951	.....	.....	.....
The Pure Oil Co.	Dollarhid, Andrews County, Texas	Nat. Gasoline Plant	22,000 mcf	$6 million	Under Constr.	July, 1950	.....	.....	.....
The Pure Oil Co.	Nederland, Tex.	Wax Plt. Add.	.....	.....	Under Constr.	Jan., 1950	.....	Staff, Lummus	Tellepsen, Lummus
The Pure Oil Co.	Nederland, Tex.	Wax Fractntn.	250 bbls.	.....	Under Constr.	Jan., 1950	Texaco	Lummus, Staff	Lummus Tellepsen
Reno Oil Co.	Holiday, Texas	Gasc. Press. Maint. Plant	400 hp.	.....	Completed	.....	None	O. L. Olson	O. L. Olson
The Shamrock Oil & Gas	Sunray, Texas	Cycloversion Unit	1,500 bbls.	$300,000	Under Constr.	Early 1950	Perco	Staff	Staff
Shell Oil Co.	Houston, Texas	Lube Utilities	.....	.....	Completed	.....	.....	Fluor	.....
Shell Oil Co.	Provident City, Texas	Gas Stripping	60,000 mcf	.....	Under Constr.	1st Qtr., 1950	.....	Fluor	Fluor
Shell Oil Co.	Nofrees, Texas	Add TXL Plant	30,000 mcf	.....	Under Constr.	Early 1950	.....	Brown & Root	Brown & Root
Shell Oil Co.	Denver City, Texas	Gas Comp. Absorp. Add.	20,000 mcf	.....	Completed	.....	.....	Fluor	Fluor
Southern Minerals Corp.	Stratton Field, Texas	Gas Compression Addition	.....	.....	Under Constr.	.....	.....	.....	.....
Stanolind O&G Co., Opr.	Fullerton Field, Texas	Gasoline Plant	55,000 mcf	.....	Under Constr.	Feb., 1950	.....	J. & L. Constr.	J. & L. Constr.
Stanolind Oil & Gas Co.	Alvis, Texas	Dehydration, Gas Sales Plt.	.....	.....	Completed	.....	.....	Staff	Tellepsen
Stanolind O&G	Brownsville, Tex.	Chemical Plant	150 tons	.....	Under Constr.	April, 1950	.....	Badger	Badger
Stanolind O&G	Levelland, Tex.	Gasoline Plant	40,000 mcf	.....	Under Constr.	Feb., 1950	.....	Brown & Root	Brown & Root
Stanolind O&G	N. Cowden, Tex.	Gasoline Plant	50,000 mcf	.....	Under Constr.	1950	.....	Stearns-Roger	Stearns-Roger
Texas Nat. Gaso. Corp. & Santa Rosa Gas Prods. Co.	Grandfalls, Pecos County Texas	Nat. Gaso. Plt.	30,000 mcf	.....	Under Constr.	Feb., 1950	.....	TNGC Staff	TNGC Staff
The Texas Co.	Tijerina-Canales Field, Texas	Gas Compression	3,000 mcf	.....	Under Constr.	July, 1950	.....	.....	.....
United Gas Pipe Line Co.	Karnes City, Texas	Nat. Gas., Condensate Process	10,000 mcf	$1 million	Under Constr.	Jan., 1950	.....	Delta	Delta
ROCKY MOUNTAIN									
Coronado Gas Corp.	Loco Hills Field, N. M.	Repressuring, Extraction	10,000 mcf	$500,000	Completed	.....	Pet. Eng.	Pet. Eng.	Pet. Eng.
El Paso Nat. Gas Co.	Lea County, N. M.	Compressor Sta.	5,500 hp.	$1.35 million	Under Constr.	Mar., 1950	.....	Staff	Staff
El Paso Nat. Gas	ditto	Gas Purif. Plt.	50,000 mcf	$325,000	Under Constr.	Mar., 1950	.....	Stearns-Roger	Staff
El Paso Nat. Gas	ditto	Gasc. Absp. Plt.	50,000 mcf	$285,000	Under Constr.	Mar., 1950	.....	Stearns-Roger	Staff
Frontier Refining Co.	Cheyenne, Wyo.	Coking, 2 Coke Crks.	2,400 bbls.	$725,000	Contracted	May, 1950	U.O.P.	Ref. Eng.	Ref. Eng.
Northern Natural Gas Co.	Palmyra, Neb.	Compressor Add.	1,500 hp.	.....	Completed	.....	.....	.....	Fluor
The Pure Oil Co.	Worland, Wyo.	Gasoline Plant	.....	.....	Projected	.....	.....	.....	.....
Salt Lake Refining Co.	Salt Lake City	Cat. Cracking	25,000 bbls.	$10 million	Design	Jan., 1951	Houdry	Bechtel-Houdry	Bechtel
Sioux Oil Co.	Newcastle, Wyo.	Thermal Crk.	1,200 bbls.	$300,000	Authorized	Early 1950	U.O.P.	Koch	Staff
*Sioux Oil Co.	Newcastle, Wyo.	Cat. Poly.	60 bbls.	$100,000	Contracted	Spring, 1950	U.O.P.	Koch	Staff
Socony-Vacuum Oil Co.	Casper, Wyo.	Topp. Revmcons	5,900 bbls.	.....	Under Constr.	.....	.....	Staff	Cpt. Constr.
Stanolind Oil & Gas Co.	Eunice, N.M.	Storage Loading Rack	8,000 bbls.	.....	Under Constr.	.....	.....	Staff	Dresser
Texas Gulf Sulfur Co.	Worland, Wyo.	Sulfur Recov., Gas Treat. Plts.	30,000 mcf	.....	Under Constr.	.....	.....	Girdler, C. F. Braun, Foster Wheeler	Girdler
WEST COAST									
Continental Oil Co.	Ventura, Calif.	Rev. to Gasc. Plt.	20,000 mcf	.....	Under Constr.	May, 1950	.....	Ref. Maint.	Ref. Maint.
Colne Gasoline Co.	Ventura, Calif.	Rev. to Gasc. Plt.	15,000 mcf	.....	Under Constr.	Feb., 1950	.....	Ref. Maint.	Ref. Maint.
General Pet. Corp.	Torrance, Calif.	H_2S Absorption	.....	.....	Under Constr.	Mar., 1950	.....	Badger	Badger
General Pet.	Torrance, Calif.	Two Coke Drums, Furnace	7,500 bbls.	$2.25 million	Completed	.....	.....	Kellogg, Staff	Bechtel

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
*General Petroleum	Torrance, Calif.	Gas Collecting, H_2S Abs. Plt.		$600,000	Under Constr.				
*General Petroleum	Torrance, Calif.	Add. Odor Abatement System		$40,000	Under Constr.				
*General Petroleum	Torrance, Calif.	Dust Collecting System to Gasc. Cat. Cracker		$25,000	Under Constr.				
*General Petroleum	Torrance, Calif.	Smoke, Fume, Odor Controllers		$250,000	Under Constr.				
Hancock Chemical Co.	Long Beach, Cal.	H_2S Recovery	30 tons	$1 million	Designing	Jan., 1950		Badger	Badger
Hancock Oil Co.	Long Beach	Ethylene Glycol	60,000 lbs.		Engineering	3rd Qtr., 1950		Badger	Badger
Paloma Refining Co.	Paloma Field, Calif.	Extend Absorption Sect.	60,000 mcf		Planning				
Richfield Oil Corp.	Cuyama, Calif.	Absorption H_2S Removal	15,000 mcf		Under Constr.			Fluor	Fluor
Richfield Oil Corp.	Cuyama, Calif.	Comp. Plt. Extn.	2,640 hp.		Designing			Fluor	Fluor
Shell Oil Co.	Wilmington, Cal.	Add. Crk. Comp.			Under Constr.			Fluor	Fluor
*Stanecal Asphalt & Bitumuls Co.	Point Wells, Wash.	Asphalt Refinery				Mid., 1950			
Union Oil Co. of Calif.	Brea Olinda, Cal.	Research Plant		$5 million	Projected	Sept., 1950			
Union Oil of Calif.	Oleum, Calif.	Revise Refg.		$4 million	Under Constr.	Feb., 1950		Parsons, E. & A.	Ref. Maint.
Union Oil of Calif.	Oleum, Calif.	Improve Handling Facilities		$1.8 million	Under Constr.	Feb., 1950		Mathews, Montgomery	Early, C. N. Peterson, Mathews
Union Oil of Calif.	Oleum, Calif.	Tankage and Utilities		$1.8 million	Engineering	Mar., 1950		Parsons	Eaton & Smith, C.B.&I., Utah
Union Oil of Calif.	Oleum, Calif.	Main Office Addition, Shops, Miscl.		$1 million	Under Constr.	Jan., 1950		Austin, Field & Fry, D. R. Warren Co., Montgomery	E. S. McKittrick, Parker, Steffens & Pearce
Union Oil Co.	Oleum, Calif.	Add. Ref. Facilities			Under Constr.	Feb., 1950			
FOREIGN									
Canada									
British-American Oil Co.	Edmonton, Alberta	Refinery	6,000 bbls.		Planning	Mid., 1950			
British-American Oil	Clarkson, Ontario, Can.	Propane Deasphalt.	700 bbls.	$400,000	Contracted	Mid., 1950	S.O.D., Union Oil (Calif.), Standard (Ind.)	Canadian Kellogg	Canadian Kellogg
Excelsior Refs., Ltd.	Lloydminster, Alberta	Cap. Increase	3,000 bbls.		Under Constr.	1950	U.O.P.	U.O.P.	
Excelsior Refs., Ltd.	Lloydminster, Alberta	Capacity Inc.	1,500 bbls.		Design	1950			
Hi-Way Refineries, Ltd.	Saskatoon, Saskatchewan	Crude Topping Unit	2,000 bbls.		Completed		U.O.P.	Ref. Eng.	Ref. Eng.
Hi-Way Refineries	Saskatoon	Thermal Crack.	500 bbls.		Completed		U.O.P.	Ref. Eng.	Ref. Eng.
Imperial Oil, Ltd.	Leduc Field	Gas Absorption	24,000 mcf	$6.5 million	Under Constr.	Mid. 1950		Braun	Braun
Imperial Oil	Regina, Saskatchewan	Add Distil. Equip.	3,000 bbls.	$380,000	Under Constr.	Jan., 1950		Staff	Staff
Imperial Oil	Winnipeg	New Refinery	10,000 bbls.	$10 million	Planning Projected	May, 1951			
Panther Oil and Grease Co.	Leaside, Toronto, Ontario	Grease and Compounding							
Shell Oil Co. of Canada, Ltd.	Montreal East, Quebec	Fluid Cat. Crk., Vac. Flash Gas Recov., Poly, Treat	35,000 bbls.		Under Constr.	Late 1950		Staff	Fluor, Ltd., McKee
*Supreme Refineries, Ltd.	Hanna, Alt.	Nat. Gaso. Plt.	1,000 mcf.	$100,000	Contracted	June 1, 1950		Staff	Staff
*Supreme Refineries	Calgary, Alt.	Refinery	1,000 bbls.	$100 million	Under Constr.	Mar. 1, 1950		Staff	Staff
Latin America									
Administracion Nacional Combustible Alcohol y Portland	Montevideo, Uruguay	Lube, Asphalt Units	7,500 bbls.		Under Constr.	1st Qtr., 1950		Foster Wheeler	Foster Wheeler
Conselho Nacional do Petroleo	Mataripe, Bahia, Brazil	Thermal Cracking Refinery	5,000 bbls.	$2.5 million	Under Constr.	Jan., 1950		Kellogg	Kellogg, Staff
Conselho Nacional do Petroleo	Santos Sao Paulo	Refinery	45,000 bbls.						
Conselho Nacional do Petroleo	Mataripe, Bahia, Brazil	Refinery		$3.5 million	Planning	Dec., 1950			
Creole Pet. Corp.	Amuay Bay, Venezuela	Crude Stills	60,000 bbls.	$175 million	Under Constr.	1950		S.O.D.	Foster Wheeler, J. G. White
Creole Pet. Corp.	El Roble Field, Venezuela	Repressuring			Planning				
Ipiranga S.A. cia. Brasilera de Petroleos	Rio Grande, Brazil	Topping, Thermal Cracking	3,000 bbls.		Authorized	1952	Foster Wheeler		
Mene Grande Oil Co.	Puerto la Cruz, Venezuela	Refinery	30,000 bbls.						
Petroleos Mexicanos	Poza Rica, Mex.	Gas Purification Pressure Maint.		$13 million	Contracted	Early 1950		McKee	McKee
Petroleos Mexicanos	Salamanca, Mex.	Crd., Gasoil, Crk.	25,000 bbls.	$12 million	Under Constr.	Early 1950	U.O.P.	McKee	McKee
*Puerto Rican Oil Refining Co.	Near Ponce, Puerto Rico	Refinery	25,000 bbls.	$20 million	Projected	1st Qtr., 1951		Parsons, Brinckerhoff, Hall and Macdonald	Lyford & Eberle
Refinaria de Petroleo do Distrito Federal S.A.	Rio de Janeiro, Brazil	Complete Refinery	45,000 bbls.		Authorized				Fives, Lille, Schneider, Staff
Refinaria e Exploracao de Petroleo Unisa S.A.	Capuava, Sao Paulo, Brazil	Thermal Cracking Refinery	20,000 bbls.		Authorized			Pan American Hydrocarbon Res., Inc.	Czech, Fact. Metal Work Mech. Constr.
Richmond Exploration Co.	Bajo Grande, Venezuela	New Refinery	35,000 bbls.		Engineering	June, 1950			
Shell Caribbean Pet. Co.	La Paz, Venezuela	Gas Plant	90 tons		Under Constr.	Early 1950			
Shell Caribbean Pet. Co.	Mara, Venezuela	Gas Plant	90 tons		Projected	Early 1951			
Shell Oil of Venezuela	Punta Cardon, Venezuela	Comprehensive Refining	30,000 bbls.	$32 million	Completed				
Venezuelan Gulf Refining Co.	Puerto la Cruz, Venezuela	Refinery	30,000 bbls.	$5 million	Under Constr.	July, 1950		Lummus	Lummus
Venezuelan Pet. Co.	Puerto la Cruz, Venezuela	Refinery	35,000 bbls.		Under Constr.			Snare	Snare
Yacimientos Petroliferos Fiscales	Buenos Aires, Argentina	New Refinery	28,000 bbls.	$54 million	Engineering	Late 1950		Kellogg	Kellogg

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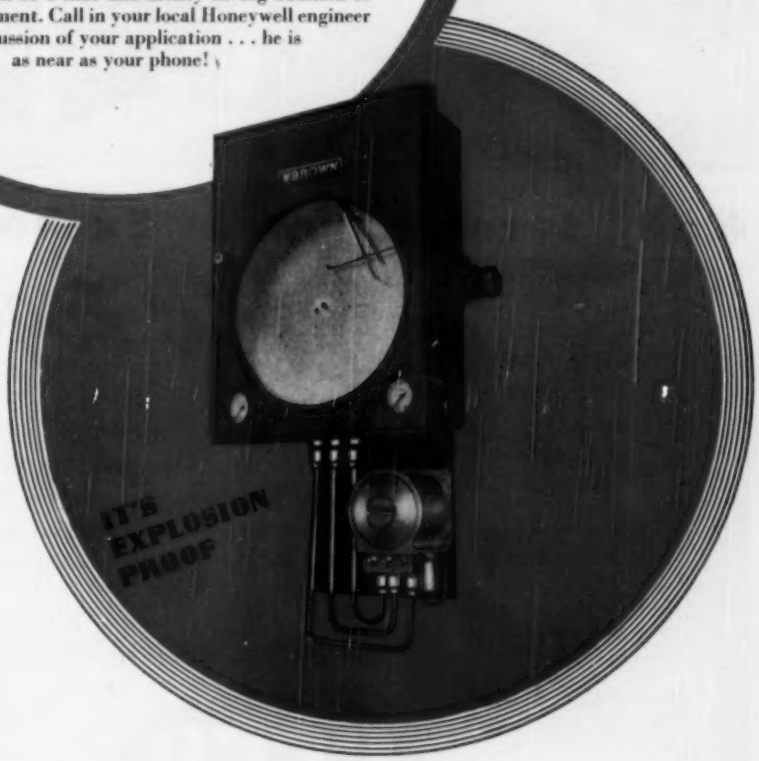

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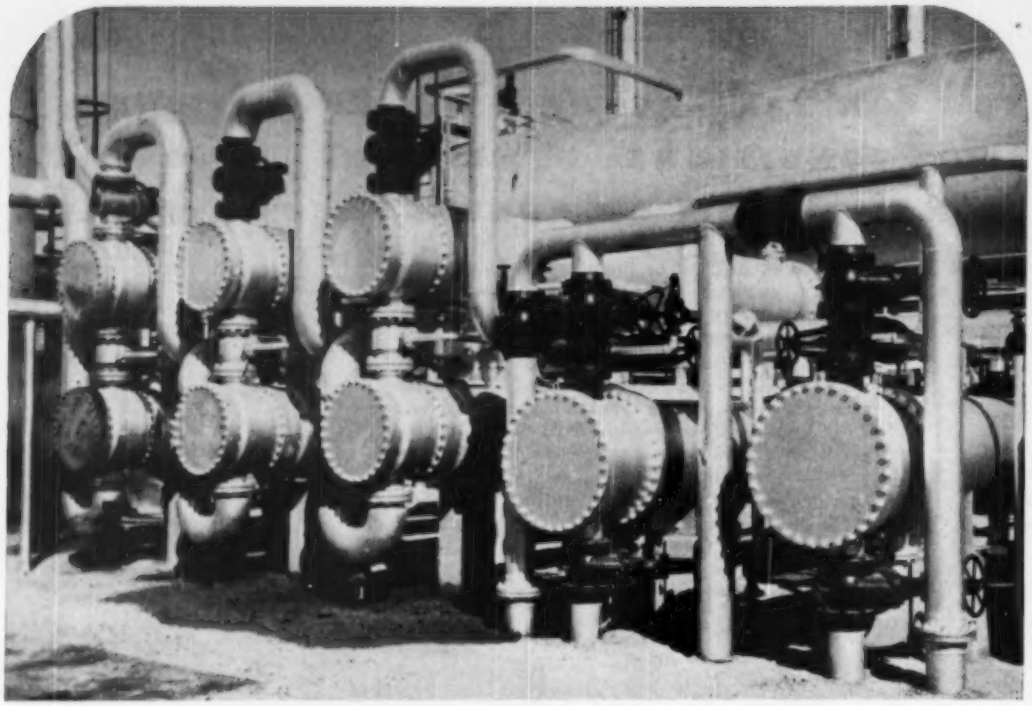

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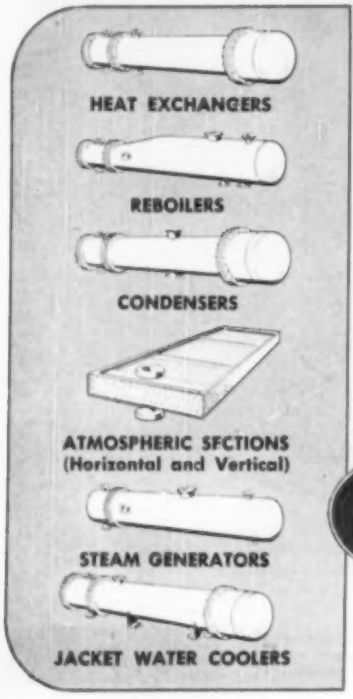

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HEAT TRANSFER EQUIPMENT

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

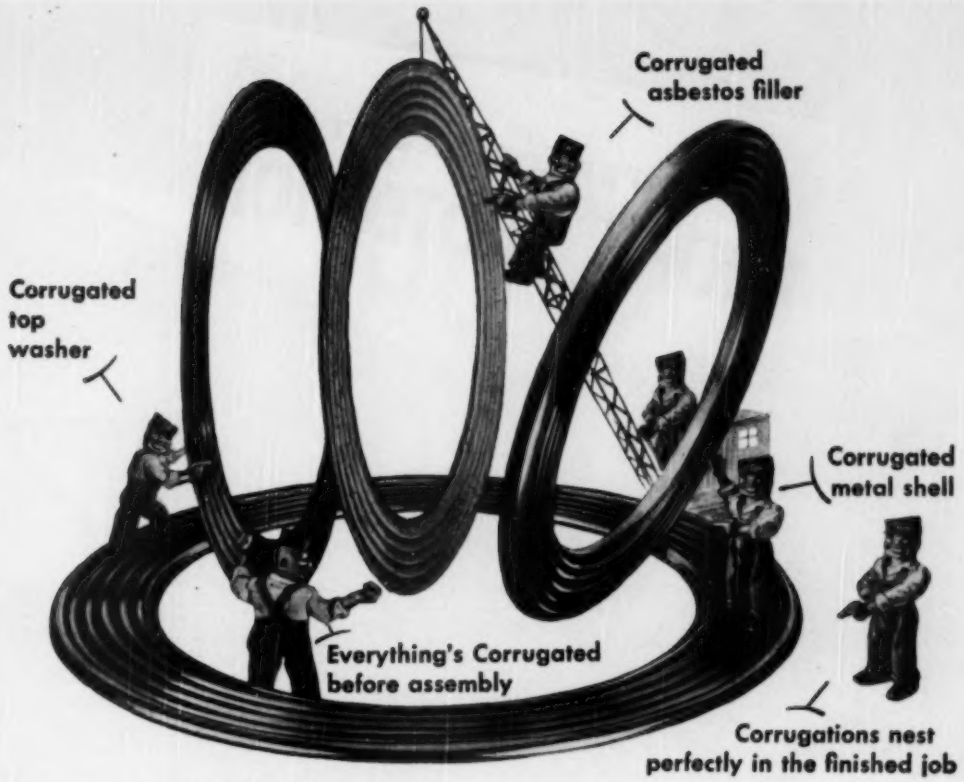
COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
YPF	La Plata, Argentina	Crude Topping, Gaso Treating	50,000 bbls.	$2.8 million	Under Constr.			Houdry Process Cat. Constr.	Cat. Constr.
YPF Bolivianos	Cochabamba, Bolivia	Topping & Reforming Units	5,000 bbls.			3rd Qtr., 1950		Foster Wheeler	Foster Wheeler
Europe and Africa									
Anglo-American Oil Co.	Fawley, Eng.	Refinery Expansion	110,000 bbls.	$150 million	Under Constr.	Late 1952		Foster Wheeler	Foster Wheeler
Anglo-American	Fawley, Eng.	SO_2 Extraction	17,000 bbls.		Design			Badger	Badger
Anglo-Iranian Oil	Isle of Grain, Eng.	Cent. Refg. Unit	60,000 bbls.	$120 million	Planning	1952			
Anglo-Transvaal Consolidated Investment Co.	Vall River, Union of South Africa	Synthetic Gasoline and Diesel Oil Plant		$50-60 million	Contracted			Hydro. Res.	
Aquila, S.A.	Trieste, Italy	Lube Oil Refinery	800 bbls.		Design	Mar., 1951	Juik, Texaco	Badger	Badger
Azienda Generale Italiana Petroli	Rome, Italy	Add to Plant	24,000 bbls.		Projected	Late 1951			
Azienda Generale Italiana Petroli	Palermo, Italy	Marine Fuel Plant	7,500 bbls.						
Bataafsche Petroleum Mij.	Pernis, Holland	P.U.C. Plant	2,000 tons, yr.			Jan., 1950			
My. Bataafsche Pet.	Pernis, Holland	Expansion	50,000 bbls.		Under Constr.	Mid 1952			
British Petroleum Chem.	Grangemouth, Scotland	Petrochem			Under Constr.	Dec., 1950		Stone & Webster	Stone & Webster
Cabot Carbon, Ltd. (Godfrey L. Cabot, Inc.)	Ellesmere Port, Eng.	Carbon Black Plant	50,000 lbs., yr.		Under Constr.	1950		Simon-Carves, Ltd.	Simon-Carves, Ltd.
Caltex Pet. Maatschappij, N.V.	Rotterdam, Holland	Complete Refinery	20,000 bbls.	$18 million	Under Constr.	Feb., 1950		McKee, Badger, U.O.P.	McKee
Cie. de Raffinage Shell-Berre	Berre, France	Expansion	40,000 bbls.		Under Constr.	Mid 1951			
Shell	Petit-Couronne	Teepol Plant	25,000 tons, yr.		Planned	Mid 1950			
Cie. de Raffinage Shell-Berre	Petit Couronne, France	Lube Unit			Under Constr.	Early 1950			
Cie. de Raffinage Shell-Berre	Petit-Couronne (Rouen), France	Expansion	10,000 bbls.		Design	1951	Texaco	Kellogg-Lummus	
Cie. Francaise de Raffinage	Gonfreville, France	Lube Unit	2,500 bbls.		Under Constr.	1950		Foster Wheeler	Foster Wheeler
Cie. Francaise de Raffinage	Gonfreville, France	Distillation Unit	20,000 bbls.		Under Constr.	1950		Foster Wheeler	Foster Wheeler
Cie. Francaise de Raffinage	Provence, France	Topping Unit	20,000 bbls.	$11 million	Contracted	June-July, 1950		U.O.P.	U.O.P.
Cia Espanola de Petroleos, S.A.	Sta. Cruz de Tenerife (Canary Islands)	Propane-Butane Fractionating, Propane-Deasphalting	304 bbls.	$100,000					
Cia Espanola de Petroleos, S.A.	Sta. Cruz de Tenerife (Canary Islands)	Propane-Butane Fractionating, Propane-Deasphalting	700 bbls	$300,000	Contracted	June-July, 1950	Standard Oil	Foster Wheeler	Foster Wheeler
Cia. Espanola de Petroleos, S.A. (C.E.P. S.A.)	Canary Islands, Spain	Furf. Ref. Sol. Dewax., Wax Fractntn.	425 bbls.	$4.5 million	Under Constr.	Early 1950	Texaco, Standard, N.J.	Foster Wheeler	Foster Wheeler
Condor, S.P.A. Per l Industriale Pet. Chemica	Rho, Italy	New Refinery	1 mln tons, yr.						
Danish Government	Denmark	Refinery	21,000 bbls.		Planned			Lummus	Lummus
Egyptian Government	Cairo, Egypt	Crude Plant							
Industrie Chimiche Italiane Petroli	Mantua, Italy	Crude	4,500 bbls.						
Industria Nazionale Petroli e Trasformazioche	Massa Carrara, Italy	Refinery	40,000 bbls.			Late 1951			
Industria Petrolifera e Chimica	Milan, Italy	Gasoline Fuel Oil Plant	20,000 bbls.					Dr. Calogero Inglogio Kellogg	
Imperial Chemical Industries, Ltd.	Wilton, Yorkshire, England	Petroleum Cracking Unit			Under Constr.	1950		Kellogg	Kellogg
Stand.-Azienda Gen. Indro. Comb. (Stanic)	Leghorn, Italy	Add Capacity	28,700 bbls.						
Ditto (Stanic)	Bari, Italy	Add Capacity	38,300 bbls.		Planned				
L'Alliance Petrofina	Antwerp, Belg.	Refinery	21,000 bbls.		Projected				
Manchester Oil Refinery, Ltd.	Partington, England	Cat. Crk., Lube Reforming	20,000 bbls.		Design	Early 1950		Staff	Staff
Monsanto Chemical Co.	Britain	Add Polystyrene			Under Constr.		Juik, Texaco	Badger	Badger
National Oil Refineries	Llandarcy, Wales	Lube Oil Ref. Refinery			Designing		Texaco	Badger	Badger
National Oil Refineries	Llandarcy, Wales	Furf. Ref. Sol. Dewax., Wax Fractn.	1,200 bbls.	$36 million	Contracted			H.W.P.	
National Oil Refineries	Llandarcy, Wales	SO_2 Solvent Extraction	3,000 bbls.		Authorized	1950			
Pechelbronn, S. A. E. M.	Merkwiller, France	Capacity Increase	1,550 bbls.						
Petro Carbon, Ltd.	Partington, England	Cat. Cracker, Lube & Reform	20,000 bbls.		Under Constr.		Petro-Carbon	Petro-Carbon	Petro-Carbon
Petro Chem., Ltd.	Partington, England	Petrochemicals	2,000 bbls.	$16 million	Contracted	1950	Phillips	H.W.P.	H.W.P.
Philblack, Ltd.	Avonmouth, England	Carbon Blk. Plt.	137,000 bbls.	$5 million	Under Constr.	July, 1951			
Ref. de Pet. de Escom. S.A.	Escombreras, Spain	Refinery	20,000 bbls.		Under Constr.	1950		Barnes	Barnes
Raffinerie Belge de Petroles S.A.	Antwerp, Belgium	Therm. Crk., Reform., Gas Plant		$2 million				U.O.P., McKee	McKee
Raffineries de Petrole de la Gironde	Bec Ambes, France	Refinery	13,000 bbls.	$7.8 million	Completed				
Raffineries Francaises de Petrole de l'Atlantique	St. Nazaire, France	Consolidate Refineries	7,100 bbls.	$9.4 million					
Socony-Vacuum Italiana, S.p.A.	Naples, Italy	Visbreaker				Early 1950		Staff	Staff
Socony-Vacuum Italiana, S.p.A.	Naples, Italy	Topping Unit	15,000 bbls.		Under Constr.			Staff	Staff
Socony-Vacuum Italiana, S.p.A.	Naples, Italy	Solvent Treating	1,000 bbls.		Under Constr.	Early 1950	Texaco	Staff	Staff
Socony-Vacuum Italiana, S.p.A.	Naples, Italy	Reformer	5,000 bbls.		Under Constr.	Early 1950		Staff	Staff
Raffinerie Sicilane Oli Minerali, S.A.	Augusta, Sicily	Crude Refinery	10,000 bbls.		Designing	Early 1950	U.O.P.	U.O.P., Delta	S. T. I. I.

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
*Scottish Oils, Ltd.	Grangemouth, Scotland	Stage I: 1 Pipe Still Distill., Steam Boil. & Power Plt.	1.5 mln. tons per Yr. 20,000 kw.	.....	Under Constr.	End 1950	.....	Kellogg	Kellogg
*Scottish Oils	Grangemouth, Scotland	Stage II: Cat. Crk., Vac. Distill., Cat. Poly Plt., & Trtng Plt.	.....	.....	Planned	Mid., 1952	.....	.....	.....
Shell Chemical Mfg. Co., Ltd.	Thornton, Eng.	Teepol Plant Extension	75,000 tons per Year	.....	Under Constr.	Jan., 1950	.....	.....	.....
Shell Refining & Marketing Co., Ltd.	Stanlow, Eng.	Comprehensive Refining	60,000 bbls.	.....	Under Constr.	Early 1952	.....	.....	.....
Shell Refining & Marketing Co., Ltd.	Shell Haven, England	Comprehensive Refining	60,000 bbls.	.....	Under Constr.	Mid 1953	.....	.....	.....
Societe Generale des Huiles de Petrole	L'Avera, France	LPG Units	25,000 bbls.	.....	Under Constr.	Mid 1950	Kellogg	Kellogg	Staff
Societe Generale	Dunkirk, France	Crude Reform.	23,000 bbls.	.....	Under Constr.	Mid 1951	Lummus, Kellogg	Lummus, Kellogg	Lummus, Kellogg
Societe Generale	Dunkirk, France	Furf. Ref. Sol. Dewax., Wax Fractn.	2,400 bbls.	.....	Designing	Mid 1951	Texaco	Lummus	Lummus
*Societe Generale	Dunkirk, France	New Refinery	6,000 bbls.	.....	Under Constr.	Feb., 1950	.....	.....	.....
Societe Industrial Belgique de Petrole	Antwerp, Belgium	Crude, Cracking Reforming	30,000 bbls.	.....	Designing	Mid 1951	.....	.....	.....
Societe Raffinazione Oli Minerali (IROM)	Porto Marghera, Italy	Atmospheric & Vac. Distill., Acid Treat., Contract Filtration for Lube Oils, Electric Gen. Unit, Lead. Facilities	1 mln. tons year	$6.4 million	Contracted	.....	.....	H.W.P.	H.W.P.
Societe per Azioni Raffineria Padana Oli Minerali	San Martino di Trecate, Italy	Refinery	13,000 bbls.	.....	Proposed	.....	.....	.....	.....
Socony-Vacuum Francaise	Notre Dame de Gravenchon	MEK Unit	1,000 bbls.	.....	Design	Mid 1950	Texaco	Lummus	Staff
Socony-Vacuum Francaise	Notre Dame de Gravenchon	Propane Desasphalting	1,100 bbls.	.....	Design	Mid 1950	Juik	Lummus	Staff
Socony-Vacuum Francaise	Notre Dame de Gravenchon	Grease and Compounding	.....	.....	Under Constr.	Mid 1950	.....	Staff	Staff
Standard Francaises des Petroles	Port Jerome, France	Dewaxing Plant	1,200 bbls.	$6.4 million	Design	Late 1951	.....	S.O.D.	Foster Wheeler
Standard Francaises des Petroles	Port Jerome, France	Desasphalting Plant	1,500 bbls.		Design	Late 1951	.....	S.O.D.	.....
Standard Oil Co., (N.J.)	Belgium	Dist. Crack.	33,000 bbls.	.....	Planned	Early 1952	.....	.....	.....
Trent Oil Prod. Development Co.	North Shields, England	Crude Plant	11,500 bbls.	$4.8 million	Plans approved	.....	.....	.....	.....
Union Petrol Refinery, Ltd.	Johannesburg, Union of South Africa	New Refinery	.....	$20 million	Projected	.....	.....	.....	.....
Near East									
Anglo-Iranian Oil	Abadan, Iran	Gas Plant	25,000 mcf	$2 million	Under Constr.	1950	.....	Badger	Badger
Anglo-Iranian	Abadan, Iran	Cat. Cracker	30,000 bbls.	.....	Under Constr.	1951	.....	Foster Wheeler	Foster Wheeler
Anglo-Iranian	Abadan, Iran	Solvent Dewax.	700 bbls.	.....	Under Constr.	4th Qtr., 1950	Texaco	Badger	Badger
Anglo-Iranian	Abadan, Iran	Gas Recov., Stab.	22,000 mcf	.....	Under Constr.	Mar., 1951	.....	Badger	Badger
Arabian American Oil Co.	Abqaiq, Saudi Arabia	Crude Oil Stabilizer	300,000 bbls.	$4.8 million	Under Constr.	Summer 1950	.....	Staff and Fluor	Staff and Fluor
Arabian American	Ras Tanura, S.A.	Ref. Addn.			Under Constr.	1950	.....	Bechtel	Int. Bechtel, Inc.
Arabian American	Ras Tanura, Saudi Arabia	Asphalt Plant	500 bbls.	$1,250	Plans Approved	1950	.....	Staff, Bechtel	Staff
Bahrein Pet. Co., Ltd.	Bahrein Island	Expansion		$8.3 million	Completed		.....	U.O.P., Bechtel	Int. Bechtel, Inc.
Bahrein Pet. Co., Ltd.	Bahrein Island	Crd. Still Util.	55,000 bbls.	$9.1 million	Under Constr.	Aug., 1950	.....	Lummus, Bechtel	Int. Bechtel, Inc.
Consolidated Red., Ltd.	Haifa, Palestine	Crude Plant	80,000 bbls.		Planned	Late, 1951	.....	Badger	Badger
Consolidated Ref., Ltd.	Haifa, Palestine	Con. Facilities	.....	.....	Under Design	.....	.....	Badger	.....
Consolidated Ref., Ltd.	Haifa, Palestine	Lube Plant	2,500 bbls.	.....	Designing	.....	Texaco, Juik	Lummus, Kellogg	Lummus, Kellogg
Far East									
Bataafsche Pet. Mij. (Shell)	Balikpapan, Borneo, East Indies	Expansion	42,000 bbls.	.....	Under Constr.	Mid 1952	.....	.....	.....
Bataafsche Pet. Mij.	Pladjoe, Sumatra	Rehab. to Comprehensive Refg.	70,000 bbls.	.....	Under Constr.	Mid 1951	.....	.....	.....
Burmah Oil Co., Ltd.	Syriam, Burma	Furf., Sol. Dewax., Wax Mfg.	1,000 bbls.	$600,000	Designing	.....	Texaco	Badger	.....
Burmah Oil Co.	Syriam, Burma	Thermafor Clay Revivification	66 tons	$150,000	Design	1950	Max Miller, Socony-Vacuum	Max Miller	.....
*Pacific Refineries, Ltd.	Honolulu, Hawaii	Butane, Asph., Gas Oil, Lt. Fretns. Refy.	3,000 bbls.	$1.5 million	Contracted	June, 1950	.....	Fish Eng.	Fish Eng
Oceania									
Australian Shell Oil Co.	Clyde, New S. W., Australia	Lubeoil Refining	250 bbls.	.....	Under Constr.	Late 1950	.....	.....	.....
Australian Shell Oil Co.	Geelong, Victoria, Australia	New Refinery		$4.8 million	Under Constr.	Late 1951	.....	.....	.....
Australian Shell Oil Co.	Geelong, Victoria, Australia	Bitumen and Lubeoil Plant	.....	.....	Projected	.....	.....	.....	.....
Australian Shell Oil Co.	Geelong, Victoria, Australia	Asphalt, Lube Solvent Extraction Plants	.....	.....	.....	.....	.....	.....	.....

* First appearance in tabulation. † Added capacity

NOTE: Badger—E. B. Badger & Sons. Barnes—W. M. Barnes & Co. Bechtel—Bechtel Corp. Bellows—W. S. Bellows Co. Blaw-Knox—Blaw-Knox Construction Co. Bowden—W. H. Bowden. Braun—C. F. Braun Co. Brown Eng.—Brown Engineering Co. Brown & Root—Brown & Root Construction Co. C.B.&I.—Chicago Bridge & Iron Works Co. Canadian Kellogg—Canadian Kellogg Co. Cat. Constr.—Catalytic Construction Co. Chemico—Chemical Construction Co. Dresser—Dresser Engineering Corp. E.&A.—Ehrhart & Arthur, Inc. Ferguson—H. K. Ferguson. Fish Eng.—Fish Engineering Corp. Fluor—Fluor Corp. Foster Wheeler—Foster Wheeler Corp. Gas. Plant—Gasoline Plant Construction Co. General American—General American Transportation Co. Girdler—The Girdler Corp. Graff—Graff Engineering Co. Grebe & Dorenbush—Grebe & Dorenbush Process Co. Hammond—Hammond Iron Works Co. Houdry—Houdry Corp. Howard-Mitchell—Howard Mitchell Construction Co. Hudson Engineering Corp. H.W.P.—Head Wrightson Process, Ltd. Hydro Res.—Hydrocarbon Research, Inc. Ind. Eng.—Industrial Engineers, Inc. J.&L. Constr.—Construction Division, Jones & Laughlin Supply Co. Kellogg—M. W. Kellogg Co. Koch—Koch Engineering Co. Koppers—Koppers Co., Inc. Knowles—Morris Knowles & Co. Knutson—Knutson Construction Co. Leonard—Leonard Construction Co. Lummus—The Lummus Co. Mahoney—Mahoney Contracting Co. Max Miller—Max B. Miller & Co. Michael Co. Mason—Mason Brothers Construction Co. Mathews—Mathews Conveyor Co. McKee—Arthur G. McKee Co. Parsons—The Ralph M. Parsons Co. Perco—(Division' Phillips Petroleum Co. Poling—Michael-Poling Construction Co., Inc. Montgomery—J. M. Montgomery & Co. Process Eng.—Process Engineers, Inc. Process Constr.—Pet. Eng.—Petroleum Engineering, Inc. Petreco—Petroleum Reetifying Co. Pritchard—J. F. Pritchard Co. Rust Eng.—Rust Engineering Co. Rust Pro.—Rust Process Construction Co. Ref. Eng.—Refinery Engineering Co. Ref. Maint.—Refinery Maintenance Co., Olnc. S.O.D.—Standard Oil Development Co. State Process Design Co. Schneider—Schneider & Cie. Snare—Frederick Snare Corp. Sollitt—Summer S. Sollitt Co. Telepsen—Telepsen Construction Co. State Engineering Co. Stearns-Roger—Stearns-Roger Manufacturing Co. Stone & Webster—Stone & Webster Construction Co. Voorhees, Walker, Foley & Smith. Waleo—Waleo Engineering. West—F. S. West Construction Co. Wohfeld—Wohfeld Construction Co. Equally owned California Texas Corp. and Socony-Vacuum Oil Co., Inc. Texaco—Texaco Development Co. U.O.P.—Universal Oil Products Co. Utah—Utah Construction Co.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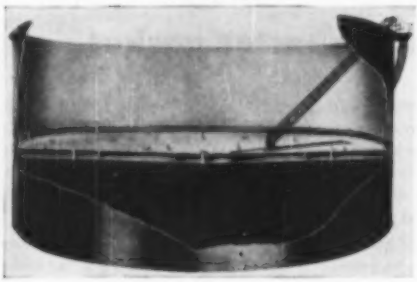

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Control Room of Naphtha Fractionating Towers.

Aliphatic Petroleum Naphthas In Industry

Part 1

H. N. FROST

The Pure Oil Company,
Smiths Bluff Refinery, Nederland, Texas

THE OIL refining industry of today is being called on more and more for hydrocarbon solvents and thinners to fit the exacting and specialized needs of many manufacturers. This should not be surprising since the physical breakdown of crude oil affords many individual compounds and groups of compounds of almost limitless variety of boiling ranges and solvencies. However, in spite of the knowledge and data the oil industry has amassed on the many crude oils and their fractions, there seems to be little tie-in between the refiner who is manufacturing the solvent or naphtha and the consuming industries who offer almost unlimited market for his products.

This article, the first of a three-part series on petroleum naphthas is concerned with the uses of such fractions in industry. A second and a third article will deal with the assay of crude oil stocks for the production of naphthas and with the manufacturing processes.

IT IS the purpose of this, the first of a series of three articles, to discuss some of the industries consuming our close boiling fractions, their needs, and their problems.

A list of the industries using petroleum naphthas are briefly given:

1) Protective coating industry.
2) Natural and synthetic rubber industry.
3) Solvent extraction and miscellaneous industries.

Paints - Varnishes - Lacquers

The protective coating industries are by far the largest consumer of aliphatic and aromatic naphthas. When one considers the many oils, resins, pigments, plasticizers, chemicals, organic solvents, etc., that go into their manufactured products, it is not surprising that they must have a wide variety of hydrocarbon solvents and thinners for their needs.

To aid in our understanding of the paint industry's products, a brief general description is given of the main classes of coatings:[1,2]

Paint: This is generally a mixture of white lead, inert pigments, linseed oil, and the necessary dryers and thinners.

Varnish: A solution or dispersion of a synthetic resin, such as a modified phenolic resin, or a

natural resin (i.e. copal, karui, rosin, etc.) in an oil vehicle (i.e. tung, linseed, perilla), with a substantial quantity of thinner.

Enamels: These are essentially varnishes, with possibly a wetting agent to improve gloss, to which are added pigments, alkyd resins along with coal-tar solvents, high solvency petroleum naphthas, or blends of these with petroleum thinners. The alkyd resins are esterification products of polybasic acids, such as phthalic anhydride or maleic anhydride, and polyhydric alcohols, exemplified by glycerol.

Lacquers: These are usually a solution or dispersion of cellulose nitrate of several different types with pigments in an organic solvent (alcohols, esters, ketones) to which is added plasticizers (dibutyl phthalate, triglyceryl phosphate, etc.), resins (synthetic or natural), along with a substantial quantity of aromatic and/or aliphatic thinners.

It is noticed from the above that thinners enter into the formulation of all types of the coatings. It might be assumed that the petroleum naphtha or thinner is indiscriminately used to increase the volume of the product and to give the manufacturer a cheap adulterant. It would be hard to conceive of a more unjust assumption. The primary purpose of a thinner in any lacquer, varnish, or paint is to render that material suitable for application. The working life, though short, of the volatile portion of a paint is highly important, and it effects the vital characteristics of the finished applied coating in the following ways:[14]

1) Ease of application.
2) Speed of drying.
3) Appearance of the dried film.
4) Performance of the dried film.

Ease of application calls for the selection of the proper thinner or combination of thinners to fit the method of application to be employed.

Brushing: The thinner must have an evaporation rate slow enough to give the applicator ample time to work the coating to a level, smooth film, but not slow enough to let the film sag or run off the work.

Spraying: The thinner must remain with the non-volatile components until the object is coated and a smooth continuous film formed. It must not evaporate when the coating is atomized. Also, its residence time must not be too long or sagging will occur.

Dipping: The thinner or thinners must be in balance with the other ingredients to obtain the required rate of evaporation and desired film thickness. The correct "drip time" or "flow out" to insure a smooth, even film must also be obtained.

TABLE 1

	GENERAL NAME OF PRODUCT	SPECIFIC PRODUCT SHOWN
1	Pentane	Amseo Pentane
2	30-60 Petroleum Ether	Amseo Petroleum Ether
3	Iso Hexane	Amseo Iso Hexane
4	Hexane	Amseo Hexane
5	Benzol Substitute	Amseo Textile Spirits
6	Iso Heptane	Amseo Iso Heptane
7	Intermediate Lacquer Diluent	Amseo Special Textile Spirits
8	Heptane	Amseo Heptane
9	Extraction Solvent	Amseo Extraction Solvent
10	Lacquer Diluent	Amseo Lactol Spirits
11	Iso Octane	Amseo Iso Octane
12	Rubber Solvent	Amseo Rubber Solvent
13	Octane	Amseo Octane
14	Close Cut VM&P Naphtha	Amseo Special Naphtholite
15	High Flash VM&P	Amseo Naphthol Mineral Spirits
16	Close Cut Mineral Spirits	Amseo 360 Solvent
17	Mineral Spirits, Stoddard Solvent	Amseo Mineral Spirits
18	High Flash Mineral Spirits	Amseo High Flash Mineral Spirits
19	High Flash Dry Cleaning Solvent	Amseo No. 140 Solvent
20	Heavy Petroleum Diluent, Paint Thinner	Amseo 460 Solvent

To meet the needs of his customers the paint formulator adjusts the *speed of drying* of his product. It is not uncommon for a company to supply the same product but with a different thinner balance to humid and non-humid areas. Although the total time required for the film to dry hard is dependent upon the type and character of the binder and driers present, the initial "set up" or "working time" is primarily due to the rate of evaporation of the thinner used, and as indicated in Table 1, this may be varied over a sizable range from a "flash dry" of three to four minutes to a slow set of approximately an hour, such as might be required in a brushing type interior wall paint.

A rough indication of the relative volatility of five petroleum fractions is given by Stewart.[1] No explanation is offered as to the method used in arriving at these drying times. Further, it is to be noticed that the boiling ranges are slightly different from the boiling ranges of some of the close cut fractions presently available.

The *appearance of the dried film* is highly important and improper choice of the thinner used can adversely affect it as indicated.

1) Rough, dry film — from dry spray application.

2) Sagging. Evaporation rate is too slow.

3) Brush-marks. Evaporation rate is too fast.

4) Orange-peel — Rough surface commonly due to uneven evaporation of thinner combinations.

5) Blushing—Whitening of the film due to too rapid evaporation of the thinner and the condensation of moisture vapor on a wet film.

In supplying suitable solvents and thinners to the varnish and lacquer trade some understanding of their problems having to do with evaporating rates of films and the physical chemistry of "solvent escape" or the "vortex" evaporating action is necessary.[1] As indicated above, a varnish or lacquer film is made of volatile and non-volatile compounds, and as it dries evaporation takes place over the entire surface. This initial evaporation of the more volatile part of the solvent causes a temperature decrease at the film's surface. If this action is too rapid the dew-point may be reached with condensation of moisture taking place and moisture blush occuring. Also as this temperature drop is experienced there is an increase in relative density at the film's surface due to a concentration of the higher boiling compounds of the solvent. The temperature and density gradients act together to produce vertical convections currents, or a flow of the warmer and less dense varnish or lacquer to the surface from the lower portions of the film.

Another factor of outstanding importance is the proper selection of the naphthas going to make up a "reducer" combination. The formulator's judgment is reflected in both the appearance and *performance* of the dried coating. The solvent strength of the

	API Gravity	IBP	E.P.	Percent of Standard Dry Time
Kerosine	45.5°	345°	525°	900
Mineral Spirits*	50.4	300	400	100
VM&P Naphtha	57.3	190	310	165½
Lacquer Diluent	60.1	200	270	10
Lighter Lacquer Diluent	71.1	140	200	5

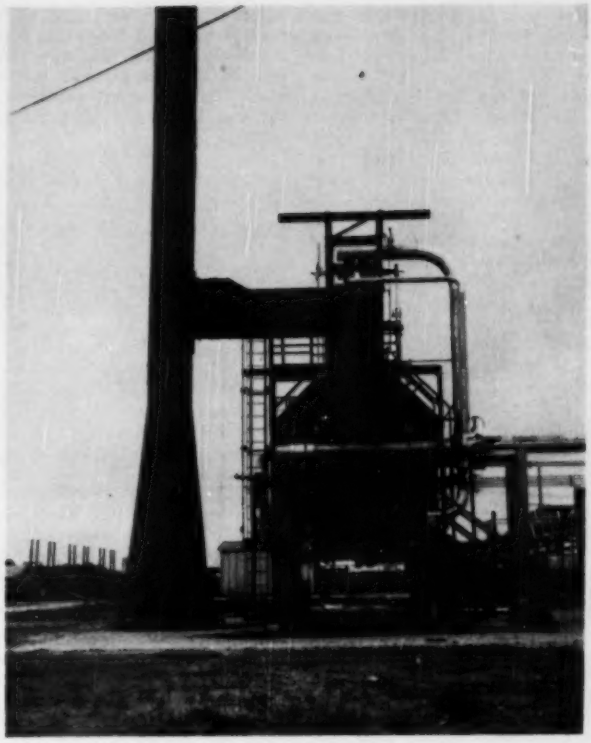
* Basis of Comparison.

"reducer" must be great enough to maintain the binder in solution at all stages of the drying process.[14]

But let's look at these "binder" combinations a bit closer. It is possible to blend a low boiling (fast) naphtha with good solvency and a high boiling (slow) naphtha with poor solvency to obtain a combination which would be compatible with a given resin. However, upon application of the coating, the fast naphtha would evaporate first, leaving the slow naphtha in the film, with the result that the resin would precipitate and a cloudy film would be obtained. In addition to the poor appearance of the coating, the performance would be inferior, due to the fact that the resin would be deposited on the work, not as a continuous film, but in the form of isolated, individual particles.

This discussion has been mainly concerned with the distillation range and/or rate of evaporation of the various naphthas used in this industry. Tables 1 and 2 give a partial list of the aliphatic naphthas now commercially available.[5] They do not list all of the naphthas, and in fact only indicate the wide range of solvents that could be made available by judicious blending.

The solvency of a naphtha is highly important particularly to the formulator employing natural and synthetic resins. Since it is generally agreed that the higher the aromaticity the greater the solvent power of the naphtha, it is not uncommon to find the aniline number, the Kauri-butanol result, the nitrocellulose dilution-ratio, and/or the dimethyl sulphate test reported as a measure of this quality.



Circulating Hot Oil Heater.

Other writers have discussed these solvency tests[7, 9, 10, 12, 13] their method

TABLE 2

Principal Tests of Selected Aliphatic Naphthas

NAPHTHA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
ASTM. DIST.																				
IBP	93	90	135	153	150	166	180	205	200	200	220	100-120	242	230	290	305	310	330	360-365	370-380
Dry Point	97	138	144	158	175-180	194		211			240		255							
End Point		140	145	159		198	210	212	230	240	243	250	257	295-300	330	360	385	395-400	400-410	460-470
Aniline Point			150	140		127		135	135	120	120	135	144	120	130	135	135	135	150	150
Flash, T.C.C.															85°	100°	102°	115°	140°	140°
Nitrocellulose Dilution Ratio			1.25	1.25	1.30	1.32	1.30	1.30	1.40	1.40	1.42		1.29	1.30						

Uses

Lacquers					Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes					
Varnishes											Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Paints												Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Flat Finishes				Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes
Rubber Tires											Yes		Yes							
Rubber Dip Goods											Yes		Yes							
Adhesives and Rubber Cements		Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes							
Rosin Extraction				Yes		Yes			Yes	Yes	Yes		Yes							
Castor Oil Extraction		Yes		Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes							
Fat and Oil Extraction	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes					
Textile Printing															Yes	Yes	Yes	Yes	Yes	
Textile Proofing					Yes		Yes			Yes				Yes	Yes	Yes	Yes	Yes		
Shade Cloth														Yes	Yes					
Floor Coverings														Yes	Yes	Yes	Yes	Yes		
Rust Proof Compound															Yes	Yes	Yes	Yes	Yes	
Dry Cleaning														Yes	Yes	Yes	Yes	Yes		
Brake Linings							Yes					Yes		Yes	Yes	Yes	Yes	Yes		
Artificial Leather				Yes	Yes	Yes	Yes	Yes		Yes	Yes		Yes	Yes						
Rotogravue Inks				Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes			
Adhesives	Yes		Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes					
Waxes											Yes		Yes	Yes	Yes	Yes	Yes		Yes	
Leather Degreasing							Yes			Yes		Yes		Yes	Yes	Yes	Yes			
Metal and Machine Cleaning														Yes	Yes	Yes	Yes	Yes	Yes	
Intermediate—Chemical	Yes	Yes	Yes	Yes		Yes		Yes			Yes		Yes							

of procedure and importance. To the lacquer manufacturer the nitrocellulose dilution ratio is most important since it tells him just how much of the petroleum naphtha can be used along with his primary solvents without throwing the nitrocellulose out of solution. Kurtz, Lupkin, and Harvey[6] purpose that "resin solvency" be determined by taking the ratio of the kinematic viscosities of definite weights of the resin to be used in a standard naphtha against an unknown naphtha. Where resin substitutions are necessary, this method offers considerable promise since it not only rates the resin, but it also allows for resin quality variation.

The relationship of Kauri-butanol solvent power to other tests is reported by McArdle and Baldeschwieler.[7] The relationship of this solvency test to the average boiling point (arithmetic average of the ASTM distillation 10, 20, 30, 70, 80 and 90 percent points) offers a comparatively safe prediction of the work performance of a naphtha of any given volatility. All too often, a manufacturer seeking a replacement naphtha overlooks slight deviations in boiling rates and average molecular weights with the result that the replaced naphtha does not quite meet his solvency needs.

There are many other requirements that an acceptable naphtha must meet such as odor, color, sulfur content and doctor test. As a rule these can be given to the oil by proper refining and treating.

The importance of proper refining should not be dismissed too lightly. If this operation is not carefully controlled the presence of active sulfur compounds in the finished naphtha may later react with the oil pigments to cause discoloration of the film. And the presence of mercaptans, or certain disulfides, have been known to cause the coating to have an objectionable odor after application. The relationship of various mercaptans to the doctor test has been reported[11] but to the best of the author's knowledge, the application of some of the recent processes for mercaptan removal, such as "mercapsol," "solutizer," and "unisol" have not been developed for complete removal of odor producing compounds in naphthas. Toby[8] reports that some progress has been made in deodorizing naphthas by the use of fuming sulfuric acid, clay treatment, and subsequent re-distillation. The objections to this refining procedure are the possibility of sulfonation taking place and all the attending evils thereof, and the removal of aromatic compounds with resulting low solvency characteristics. If the work being done by Beck and Miles at Yale[17] will give us some reliable means of measuring odor, it is entirely possible that future solvents will be tailored to meet individual needs just as they are produced now to meet exacting boiling range requirements.

Rubber Solvent

In the rubber industry as in the protective coating industry many substitutions and adjustments had to be made during the war years. And while the paint manufacturer was looking for replacements for pigments, drying oils, resins, naphthas, chemicals, etc., the rubber manufacturer was experimenting with GR-S (butadiene-styrene) rubber, butyl (isobutylene-isoprene) rubber and many others as well as many combinations.

As is seen from Table 2 the manufacture of tires, dip goods, cements, and adhesives call for solvents in the lower boiling ranges. While this is generally true, the writer has known of crepe rubber dissolved in 100 vis pale oil being added to cup greases to impart long tenacious fibers. And British Patent 2668 (November 27, 1855) calls for a small amount of elastic hydrocarbon such as East Indian or Para Caoutchouc to be added to a lubricant after first being dissolved in a hydrocarbon oil at 80° F. (176° F.) to 150° C. (302° F.).[4]

As far back as 1927 the rubber industry was using such petroleum compounds as pentane, hexane, heptane, octane, nonane, and decane as solvents as well as larger quantities of petroleum naphthas of wider boiling ranges.[3] The naphthas when admixed with sulfur chloride were employed in the cold vulcanization process.

Saturated petroleum naphthas (approximately 120° F. i.b.p. and 250° F. e.p.) are used in the building of tires to secure adhesion between the ply and tread stocks before vulcanization. During the war it was found that GR-S rubbers exhibited less tack than natural rubbers and other solvents and methods were examined. The Allied technologists who moved into Germany shortly before and after V-E Day found that these people were using "koresin" (a tertiary butyl phenol-acetylene condensation product) to import tackiness to GR-S rubber. German reports were to the effect that "koresin"—dissolved in organic solvents with a high percentage of gasoline (naphtha)—on ply stock made possible the building of tires without a post-calender cement dip.[15]

In tire as well as rubber cement manufacture problems of volatility similar to those experienced by the paint industry are common. The product for the particular operation must not be too volatile and yet it should vaporize without too great a time lapse. And since heat in one manner or another is applied during vulcanization for the production of dip goods, the most serious drawback of petroleum naphtha is its low flash point. This shortcoming has caused the industry to turn to other solvents such as carbon tetrachloride and the chlorinated derivitives of ethane and ethylene. In spite of this petroleum naphthas continue to enjoy wide popularity since they are relatively inexpensive, nontoxic, and adaptable to many exacting operations.

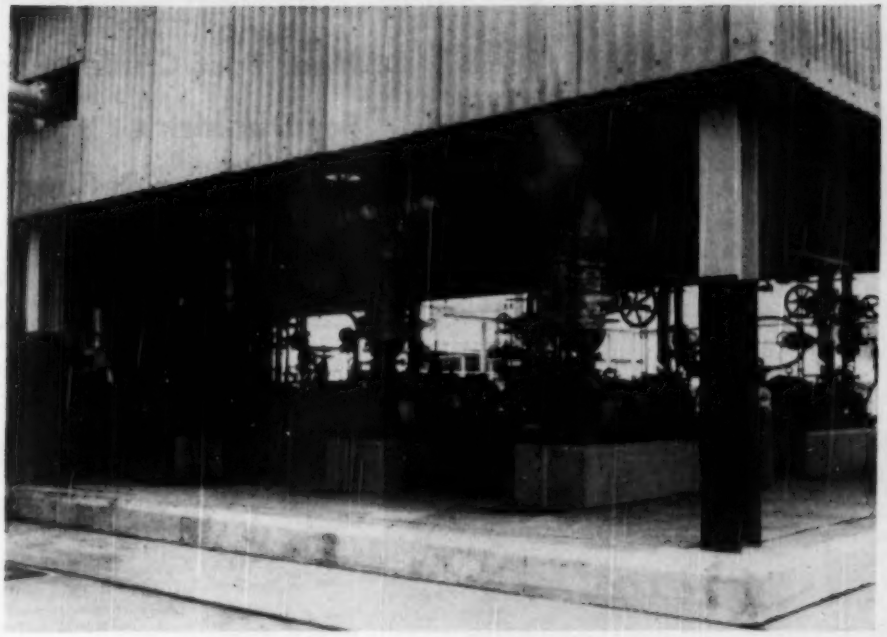
A suitable naphtha for tire building, rubber cements, and dip goods must have a moderately high i.b.p.—to allow safe handling—be of good odor—especially so for dip goods or moulded rubber manufacture—and it should be chemically stable—the presence of even small amounts of olefins or unsaturates will cause undue aging of the finished rubber product.

Extraction and Miscellaneous Solvents

The versatility of petroleum naphthas is being recognized and employed in the extraction industry to a marked extent today. While still a major part of these naphthas are going to the dry cleaning people the quantities being used in oil extraction and vitamin manufacture are assuming more importance.

Stoddard solvent, or cleaners naphtha, as now marketed more often than not exceeds the Bureau of Standards specification "Commercial Standard CS3-40." Volatility, flash, and odor are the prime requisites. A close boiling cut with a high flash will allow the cleaner to process a greater number of garments with a maximum degree of safety. And since the olfactory sense of the public being what it is, the naphtha must not only have a minimum of sulfur and be "doctor negative," but the hydrocarbons going to make up the naphtha must be capable of imparting a satisfactory residual odor to the article cleaned. It should go without saying that quantities of unsaturates are not permitted.

In the extraction of fats—both vegetable and animal—and waxes, volatility and chemical inertness are most important. The correct volatility for the particular extraction operation must be selected; and the naphtha having that volatility cannot be chemically reactive to the extracted product either during the working cycle or during the stripping operation. For these reasons it is not surprising to find almost pure hydrocarbons being used



Pump Room for Transferring Solvent Naphthas.

and experimented with today. McArdle[8] has observed that wide range naphthas are employed in the extraction of some vegetable oils when steam is employed to hold the solvent loss to a low figure. In spite of this the trend is to use commercially pure close boiling fractions (propane, pentane, hexane, heptane, etc.) for vegetable and animal oil recovery. The fact that these narrow range hydrocarbons can be stripped from the matrix, and oil recovered relatively easy, thus permitting their re-use, has led to the design of proper recovery equipment. Just recently one of the larger engineering companies[16] has introduced the "Solexol" process for glyceride oil extraction. This process employes propane as the solvent and cold fractionation as the physical means. Rather remarkable yields are reported on the following extractions: soybean oil, sardine body oil, linseed oil, shark liver oil, tallow oil, and mixed fatty acids.

It is becoming increasingly difficult to find an industry that either does not use a petroleum naphtha directly or indirectly in their manufacture. Volatility, solvency, safety in handling, chemical inertness, good odor, good color, non-toxic qualities, stability, and cost are all balanced to meet the needs of those making shoe polishes, automobile polishes, patent leather, oil cloth, rotogravure inks, wood preservatives, naphtha soaps, insecticides, marine finishes, sand paper bindings, rust preventative compounds, metal parts cleaning, degreasing metal, machine cleaning, adhesives, brake linings, textile proofing, textile printing, cigarette lighter fluid, etc.

As has been pointed out in this article the distillation range or volatility of the naphtha can be varied over a wide range to fit the needs of just about any manufacturer's requirements. The oil industry is alert to this widening market and complex but versatile equipment has been and is being installed to make available and increase the quantities of these narrow boiling solvents. By understanding the needs of our consumers we can more intelligently apply our knowledge to aid in solving their problems.

ACKNOWLEDGMENT

Acknowledgment is made of The American Mineral Spirits Company's and E. M. Toby, Jr's. approval to use trade names of products and boiling range specifications.

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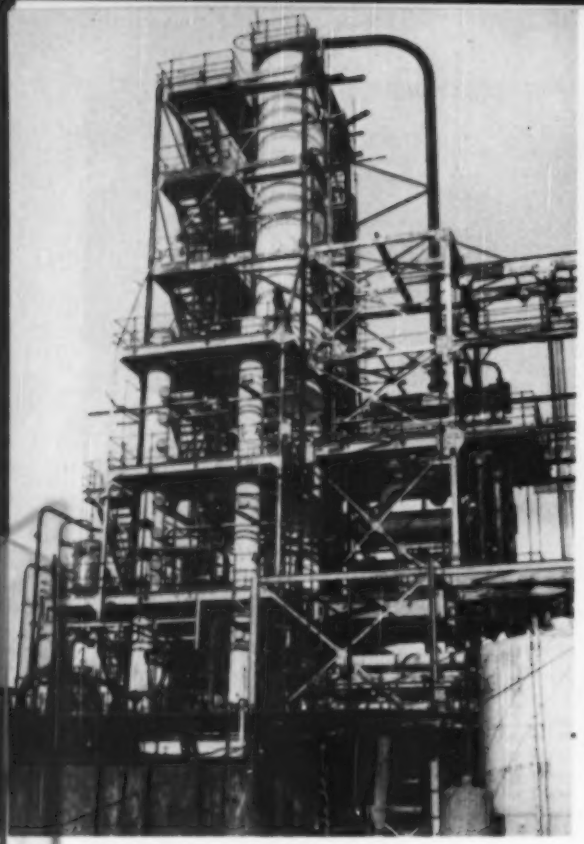
(End of Part I. Part II will appear in an early issue.)

* * *

Near East Crude For Dunkirk's Modernized Refinery



View of distillation section of enlarged refinery at Societe Generale des Huiles de Petrole at Dunkirk, France.

MIDDLE East crude from Persia and Kuwait, the first to arrive since the war, is to be regularly supplied the new Dunkirk refinery of Anglo-Iranian Oil Company's affiliate, Societe Generale des Huiles de Petrole, upon completion of the refinery, which was scheduled for early February. With the recent arrival of its first postwar cargo of crude oil, discharged by the 11,500-ton tanker, Kobad of the Associated Petroliere fleet, Dunkirk, one of the principal ports of northern France, resumed oil traffic with the Middle East, formerly interrupted by the war.

The plant which has been under construction since 1947 will embody many up-to-date technical processes and will manufacture a complete range of products including bottled gas, solvents and lubricants. One piece of equipment, a crude distillation unit, transferred in 1948 from the Courchellettes refinery of Societe Generale des Huiles de Petrole, was to begin operations in January at 2.2 millions barrels a year. Also, a large gasoline capacity is programmed which will enable it to produce both motor and aviation spirit in considerable quantities. By autumn 1951, the company plans to raise the capacity to 10.4 million barrels a year.

Installations of the plant are grouped on an enlarged site of the pre-war refinery of Raffinerie de Petrole de Nord which had a capacity of 3.7 million barrels a year and, which, with the nearby Courchellettes refinery of Societe Generale des Huiles de Petrole, supplied the markets of northern France. Under the French postwar plan of industrial concentration, the war-bombed refineries were reconstructed as a single unit, the refining license of RPN being transferred to SGHP which initiated the construction, after clearing the foundations of the old refinery and removing the remains of the plant which had been almost destroyed during the war.

In addition to its refining operations, the Societe Generale des Huiles de Petrole has a controlling interest in the Association Petroliere tanker fleet of twelve ships. These include the tankers Kobad, the Fernand Gilabert, the l'Ardeshir, the Bahram, the Lavera, the Los Angeles, the Prairial and the Floreal.

Below, left—A Dunkirk refinery in flames after 1940 bombing. It was later dismantled by the Germans, but now has been rebuilt and expanded.

Right—Tanker Fernand Gilabert used to bring oil from the Near East to France's rebuilt refinery at Dunkirk.

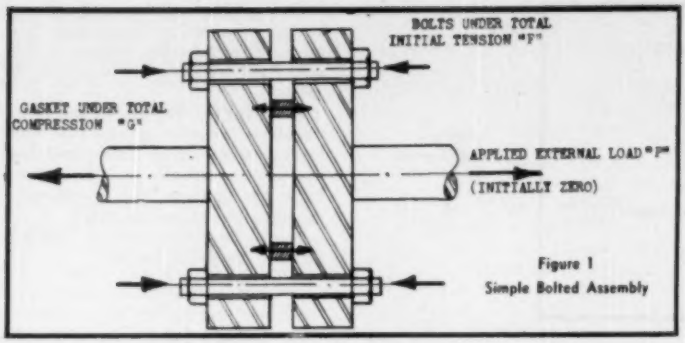


Figure 1
Simple Bolted Assembly

Bending Moments and Leakage At Flanged Joints

PART I

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THIS article is concerned directly with the problem of finding simple criteria which will show whether the joint will or will not leak. The complementary problem of determining the stresses in the flange material (under pressure load) has been well covered by many investigators, notably Messrs. Waters, Wesstrom, Rossheim and Williams in the United States. Some extension is necessary, however, to include the effect of bending moment.

If the published gasket coefficients and constants are accepted as a provisional basis, the analysis is fairly simple. These various coefficients and constants are presumably determinate for pressure loads, and have been established with the idea of providing a pressure-tight, or leakproof design.[1] If external bending moments can be broken down in some simple manner that shows how they affect gasket pressures, then these modified gasket pressures can be compared with the gasket coefficients, and the pressure-tightness of the joint including the effect of bending-moment evaluated along standard lines.

Since simplifying assumptions often lead to clarification of problems, it is of value to search for some simplification at this point. One possible assumption is the following:

> That the external moment is restrained (internally at the junction of the flange faces) exclusively by a redistribution of the gasket pressures. That is, increased pressure on the compression side of the "neutral" axis, and decreased pressure on the "tension" side of the axis, and that the bolt load is not affected.

Before using such a simplifying assumption, it is worthwhile to try to justify it. It can in part be justified by reference to Figure 1, which represents a simple kind of bolted assembly. If P is zero, and F, the initial bolt tension, is 100 pounds, then G, the initial gasket compression, must be 100 pounds. With P given some value, several types of behavior are possible.

***FLANGED JOINTS** are of major importance in the design of petroleum plants. Yet the problem of their behavior under forces other than pressure loads has received little recorded thought. If a flange leaks in service, the gasket is replaced. Or perhaps the construction crew just heaves up on the wrench handle. In extreme cases the piping may be revised. The problem, once repaired for a particular case, can again return in another plant—generally is again repaired, and promptly forgotten. Unfortunately it may periodically recur as a maintenance headache.*

This article presents a simple method for the analysis of flanged joints under a bending-moment load due to weight, expansion, or the like, acting about the joint. The conclusions have been derived from a basis of theory, because of the absence of experimental data. Since every set of experimental data needs some theoretical basis—first to determine what data to accumulate, and second to make possible an evaluation of that data—the analysis is presented also with the thought in mind that some such investigation might be stimulated.

1) If the gasket is relatively inflexible, compared with the flexibility of the bolts and flange, the bolt load will remain constant[2] until P equals the total (initial) bolt load (since the bolts can apply more load only by stretching, and if they stretch, the flanges separate. As the flanges tend to separate the bolts immediately tend to force them together again). The gasket load will then be zero, and has decreased at a uniform rate as P was increased. If the load P is further increased, the total bolt load will increase to equal P, but the gaskets will have lost contact with the flange faces. 2) If the bolts and flange are relatively inflexible compared to the flexibility of the gasket, the bolt load will increase as the load P increases. The gasket load will remain constant, and in contact with the flange faces. 3) If the bolts and flange are of about the same order of flexibility as the gasket, the gasket load will decrease and the bolt load will increase, to about the same extent.

Behavior[1] is more or less implied in standard flange design methods, as shown by reference to the API-ASME code, Section W-317, where H_G (which amounts to the gasket load) is taken as W-H (H = total hydraulic end-load, W = total bolt load). It should be noted that despite the fact that the code goes to great lengths to *avoid defining the gasket load*, the implication is there. So that, using behavior[1] as the most probable, we partly justify the simplifying assumption that the external moment is restrained almost exclusively by a redistribution of the gasket pressures. British investigations have also indicated that there is no great change in bolt load during application of hydraulic load. The gasket, once yielded, is most likely a relatively inflexible thing, compared to the axial flexibility of the bolts and the twisting or rotating flexibility of the flange. Figure 2 shows the gasket acting as a fulcrum, the metallic flange segment acting as a stiff lever, the bolts represented as a spring, the "twisting" effect of the flange as a thin rod in torsion,[3] capable only of supplying a *moment* load, and the external load represents any kind of axial load (hydraulic, axial thrust, etc.) applied to the pair of flanges. Inspection of the figure shows that, if the external load equals the bolt load, then the fulcrum load is zero. Since the flange can supply only the "twisting" resisting moment[4] necessary to keep the system in equilibrium, and no force-loads, it is evident that the gasket load must always equal the algebraic sum of the bolt load and the external load.[5]

It should be re-emphasized here, that this article is concerned immedi-

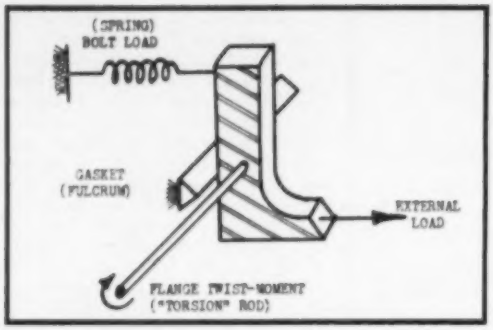


Figure 2.
Flange Segment Symbolized

ately, not with the flange stresses, but with criteria for determining if the joint will or will not leak. Although, naturally, if the flange is not strong enough to begin with, the joint presumably will leak. However, the fact that the *flange* may not be *overstressed* does *not* determine that the joint will *not* leak. Present flange stress analysis methods are relatively well-known and reliable.

Having hypothetically established the idea that the external moment is restrained almost exclusively by a redistribution of the gasket pressures, it is necessary to determine possible redistribution patterns, so that some kind of boundaries for this "no leak-leak" criterion can be worked up.

Since the gasket is not acting in an elastic range, and for all practical purposes can be considered to change insignificantly in thickness, several possibilities present themselves. Figure 3 shows a cross-section of the gasket, and next to it a "standard possibility" for the way the gasket is loaded, when under direct (bolt and pressure) loads and bending loads.

Figure 4 shows a cross-section of the gasket, and next to it a "maximum possibility" for the way the gasket can be loaded, under direct and bending loads. Several other configurations are examined in the last sections of this article.

Since one of the "best" conditions would be the "maximum possibility" case, minimum requirements can be determined by working with that case.

Since many designers use the analysis forms in the excellent treatise "Modern Flange Design" published by the Taylor Forge Company, the writer will use the same notation. The nomenclature cross-references some of these terms with those in the API-ASME code.

Using the recommended gasket constant "*m*," the minimum total gasket load can be expressed as "*m*" times the internal pressure times the effective gasket area. Stated mathematically,

$$H_{oa} = 2b\pi Gmp$$

This establishes the *minimum* total gasket load not to have leakage.

"Modern Flange Design" recommends that the unit load on the gross gasket area should not exceed twice the gasket yield load.

This establishes the *maximum* gasket pressure not to have gasket crushing (and, presumably, leakage will be associated with any crushing of the gasket).

Referring to Figure 4, and using the above two relationships plus a defined quantity "H_{oy}" (the yield load necessary to initially seal the gasket), by a few mathematical operations it can then be determined that:[6]

I. to avoid gasket crushing (and presumably attendant leakage),

$$H_m \leq \frac{4\ H_{oy} - H_o}{2}$$

II. to avoid leakage due to insufficient gasket pressure,

$$H_m \leq \frac{H_o - H_{or}}{2}$$

where $H_m = \frac{\pi M}{2G}$, and M = external moment in inch pounds.

If gasket crushing is discounted as the factor in leakage, then II becomes the criterion for determining leakage. If H_m exceeds $\frac{H_o - H_{or}}{2}$, then the flange most certainly will leak. *Provided* that the initial assumption, that the gasket is relatively incompressible, holds true.

Using the $H_m = \frac{H_o - H_{or}}{2}$ criterion on the example shown in "Modern Flange Design" (a 4½-inch thick flange for 33-inch o.d. pipe, operating at a pressure of 400 psi. and 750° F.):

$$H_o = 151{,}000$$
$$H_{or} = 107{,}000$$
$$H_m = \frac{\pi M}{2G} = 22{,}000$$
$$M = \frac{44{,}000 \times 34}{3.1416} = 475{,}000 \text{ inch pounds}$$

If the moment exceeds that value,

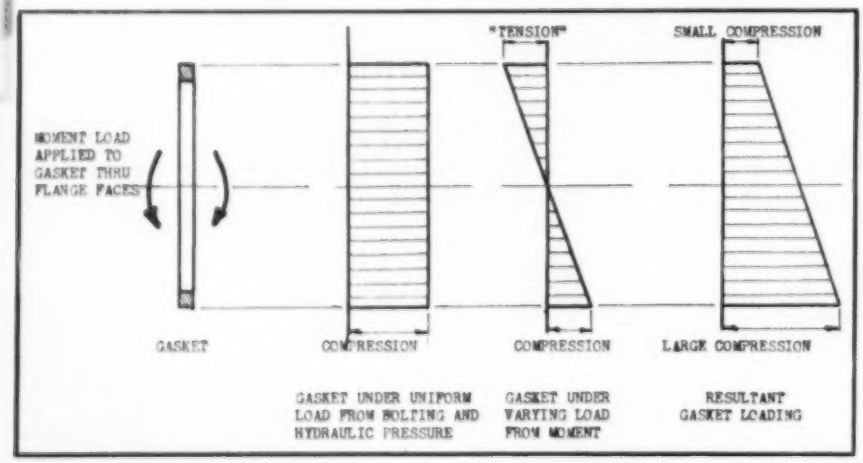


Figure 3.
"Standard Possibility" for Gasket Loading

then the joint almost certainly will leak.[1] This does not mean that a moment less than 475,000 inch pounds would *not* cause leakage, since the *maximum possible* value has been determined.

It is interesting to note that, using half-inch wall pipe in this case, the pipe stress involved due to the 475,000-inch-pound moment (only) would be about 1200 psi.—which is indeed a small value, compared with the allowable stress of 10,400 psi. This shows that there is wisdom in *trying* to locate flanges at points of low bending moment—but unfortunately this cannot always be done.

The writer does not possess economic breakdown showing the evils of flanged-joint leakage. However, it is certain that there is appreciable earnings-loss from periodic maintenance shutdowns. If a reasonably practical method can be worked out to determine the effects of moment-loads on flanged joints, then certainly the small investment in engineering cost will be well justified. It is surprising that nothing has been done to establish "moment ratings" for flanges, considering that codes specify the pressure-temperature ratings. This is probably because the pressure-temperature characteristics are more obviously related to safety, whereas the presence of bending moment primarily influences the pressure-tightness of the joint. But if flanges leak, an explanation why this happens, and a simple analysis procedure to prevent it, is certainly desirable. The following sections of this article further expand several ideas in the direction of developing such a procedure.

NOMENCLATURE

H_p or H_{Gp}	Total gasket load required to hold pressure without leagage
2b	Effective operating width of gasket
G	Mean gasket diameter
m	Gasket coefficient—ratio of the required gasket pressure to the internal hydraulic pressure
p	internal hydraulic pressure (psi.)
H_y or H_{Gy}	Total gasket load required to initially yield (set) the gasket
H_G	Total gasket load
M	Bending moment (inch pounds)
n	Total gasket width
y	Gasket constant—"yield" stress (psi.) of the gasket material
A_b or A_B	Total bolting area (sq. in.)
S_b or S_{op}	Operating bolt stress (psi)
C	Diameter of bolt circle
$\frac{1}{K}$	Coefficient used to multiply the hydraulic end load to obtain the change in bolt load [assumed to decrease in formulas (10) and (11)]
Δ_B	Change in bolt length } Typical
Δ_{FB}	Change in bolt force } Typical
Δ_M	Change in moment
E_B	Elastic constant of half the bolt length = #/" ≈ $\frac{\text{Total Bolt Area} \times \text{"E"}}{\text{Grip Length /2}}$
E_G	Elastic constant of half the gasket thickness = #/" ≈ $\frac{\text{Gasket Contact Area} \times \text{"E"}}{\text{Gasket Thickness /2}}$
E_F	Elastic constant of the flange = "#/Radian = $\frac{\text{Total Bolt Load} \times \text{Lever Arm}}{\text{Resulting Angular Rotation in Radians}}$

NOTES

[1] Reduced to essentials, the pressure on the gasket contact surfaces should not be less than "m" times the internal pressure, nor be so great that an "ultimate compression allowable" (that depends on the gasket yield point) is exceeded. These constants are generally found in the API-ASME code, Section W-317. They are not mandatory.

[2] Or in fact may decrease somewhat.

[3] Although, of course, the flange is not under "torsion" as such.

[4] Tending to turn it inside-out.

[5] If the bolt load is assumed to decrease with application of external load, the gasket load must always equal less than the algebraic sum of the *initial* bolt load and the external load. By proceeding on the assumption of a constant bolt load, results may be obtained which are less obscure, and which do not prevent subsequent corrections for changing bolt-load. It can be readily seen, for instance, that if the flange is extremely flexible rotationally, it will behave exactly like a lever. In that case, the bolt load reduction would depend on the relative distance of the external load to the fulcrum and the bolt load to the fulcrum.

[6] Assuming the simplest type of gasket.

[7] "Leakage" is a vague term. Almost all joints continuously leak to some small extent. It would be more correct to say that, "the joint is definitely operating outside the recommended limits for reasonable assurance of negligible leakage."

End of Part I. Part II will appear in an early issue.

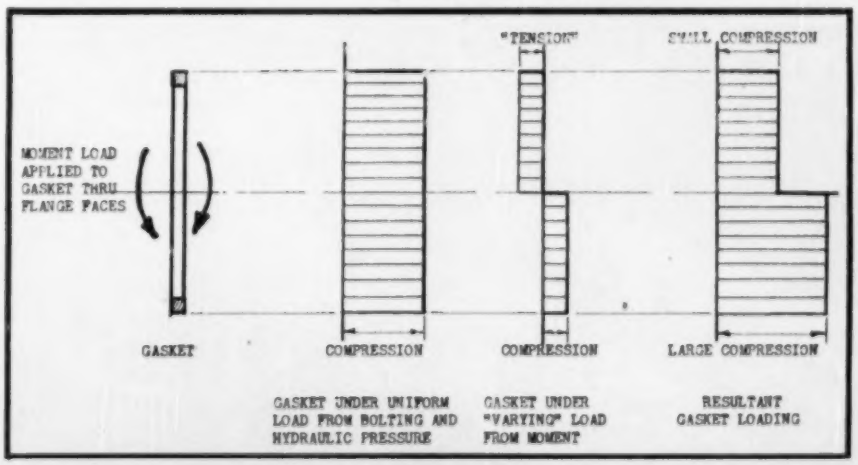


Figure 4. "Maximum Possibility" for Gasket Loading

The analytical chemist shown at left is setting up a series of fragile glass units to extract lube oil. A wide variety of experiments and tests have been conducted at Houston since a new Shell lube oil refining plant began operation there.

A Refinery's Watchful Eye

Trained Technicians Work in Modern Product Control Laboratory

THE work of chemists and technicians who "check every step in refining for product quality and uniformity" is typified by the photos on this and the page opposite, photos made at the Deer Park (near Houston) refinery of Shell Oil Company, Inc., which last year opened a new control laboratory, called "a model of modern building design and efficient layout."

This modern set-up, Shell officials explain, is in line with the company's announced endeavor "to provide the best in equipment, housing, arrangement and safety" for its 125 employes who function on a round-the-clock schedule with some 1500 tests every day.

"Before they put the seal of approval on a batch of anything from high octane aviation gasoline to asphalt, the product most likely will have been tested dozens of times, day and night," a recent statement declared. "At the same time analytically-minded laboratory employes work out process specifications, and make sure the materials used in manufacture are of high quality."

The laboratory is situated conveniently in the heart of the refinery and space for future expansion is provided. The control laboratory has 25,000 square feet of floor space, is air conditioned and sound proof. Half-glass partitions aid visibility in both laboratories and offices.

The main section of the building houses the analytical-experimental division and the effluent control laboratory, administrative offices, conference rooms, library, bottle washing room, stock and storage rooms. Maintenance rooms are set aside for an electrician, instrument man, pipe fitter and mechanic.

The technical division wing contains the Podbielniak and other precision distillation columns, and small laboratories for specific analysis and evaluation. The inspection division is in the opposite wing. Routine tests for sulfur, viscosity, flash and fire, gravity, corrosion, sta-

Data are recorded on standard forms while distillation tests are being run on refinery gasolines to make sure that they meet specifications. A sample is put into the electrically heated distilling apparatus. From pre-determined specifications, the tester knows that a certain amount of product should be distilled off into the glass graduates at given temperatures.

To test the oxidation stability of a lube oil, a sample will be placed in a Continental oxidation bath. Tendencies of the lube oil to form sludge or to increase its viscosity thus will be determined.

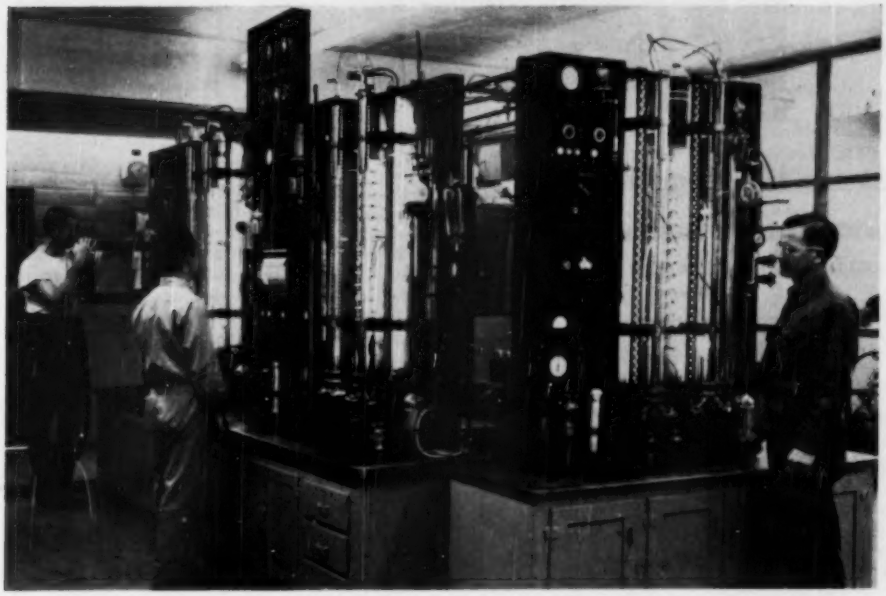
bility, etc., are made here. Wax, grease and asphalt products are tested in special laboratories in this wing.

The motor laboratory, a part of the inspection division, has its separate building immediately to the rear of the inspection wing. In addition to being sound proof, the building has two air-conditioning systems, one for the test engines and one for the building in general.

Safety facilities of the control laboratory include remote-control fog nozzles and emergency showers in case of fire or chemical burns. Escape hatches, fire extinguishers and fire blankers are provided throughout.

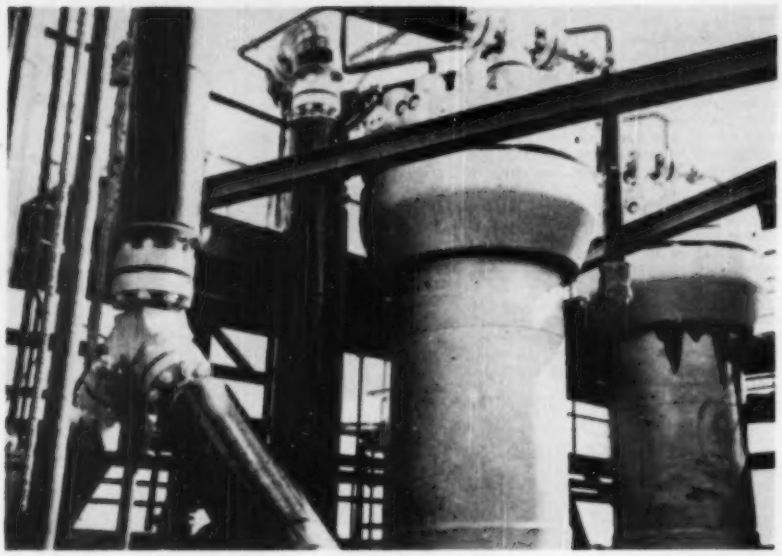
Besides affording fresh air for all working areas, the air-conditioning system minimizes odors or pockets of explosive gases. All utilities of the main building can be reached from the basement.

The new control laboratory, above, is located in the heart of Shell's Houston refinery property



The control laboratory uses small, sensitive fractionating columns for some product analysis when chemical separation is not practicable. One type of fractionator is the Podbielniak column shown above. Special tests are operating three of the "Pods" to test petroleum gases. Liquid air is used to condense the highly volatile hydrocarbons so the separation between them can be more accurate. One purpose of such tests is to check the efficiency of the huge fractionating columns in the refinery.

A special tester, photo at right, runs the lamp test for sulfur on several samples at once. The lamp tests are ordinarily used for detecting the presence and the amount of sulfur compounds in the lighter distillates and gasolines. The sulfur laboratory is a part of the inspection division of the control laboratory.



Close-up View of High-Pressure Hot Catchpot.

High-Pressure Hydrogenation Of Carbonaceous Matter

PART III—PRIMARY HYDROGENATION IN THE LIQUID PHASE (Continued)

PETER W. SHERWOOD
Koppers Company, Inc., Pittsburgh

AS NOTED IN the introductory article of this eight-part series, proper planning for the maintenance of adequate liquid-fuel supplies in the United States must eventually include the construction of a synthetic fuels industry based on coal. High pressure hydrogenation shows certain advantages over the Fischer-Tropsch process for the manufacture of aviation gasoline, fuel oils, and specialty products and merits consideration in our long range planning.

In this present article the effect of operating variables on hydrogenation in the liquid phase is discussed. Selection of proper vehicle, temperature, pressure, throughput are essential and depend on the raw material being processed and on the desired product. The product of high-pressure hydrogenation is a complex mixture of hydrocarbons and tar acids and bases. There is a striking correlation between the nature of the raw material and the products of the liquid phase. Tar acid recovery schemes employed in hydrogenation plants are derivative of coal-tar practice.

Subsequent chapters of the series will appear in early issues.

The Effect of Operating Variables in the Liquid Phase

I. Vehicle

It has already been pointed out that probably the most important reasons for adding pasting oil to hydrogenation coal are of a mechanical or operating character. It should, however, also be noted that the presence of a vehicle has a definitely favorable effect on the conversion of coal in the presence of moderately active catalysts. This observation is less pronounced in the case of active catalysts such as tin oxalate, although dry hydrogenation generally calls for larger catalyst concentrations.

Bridgwater[1] reports that no appreciable extent of coal hydrogenation can be observed below 750° F. in the absence of a suitable vehicle and catalyst but that the reaction becomes quite rapid above 820° F. under such conditions. The conversion is increased markedly by the addition of a vehicle, even in the absence of a catalyst. Bridgwater's work (as well as earlier work by Horton and co-workers[2]) indicates that, in the presence of an active catalyst, the main advantage of a vehicle is an increase in the rate of hydrogen absorption. It is probable that the coal generates its own vehicle in the presence of a good catalyst and that "dry" hydrogenation actually ceases after the first few minutes of operation.

The vehicle provided in industrial operation is generally the heavy oil obtained in the liquid phase. This material satisfies the requirements for a good coal solvent which have been outlined in Part II of this series (PETROLEUM REFINER, January, 1950): Presence of hydroaromatic and phenolic compounds.

Under certain conditions (e.g. when heavy oil is one of the desired products) it is possible to substitute middle oil for a portion of the heavy pasting oil. This does not seem to raise the gas formation but does increase the production of gasoline somewhat and reduces the formation of new middle oil.[3] This mode of operation requires special compensation for the thickening of the paste in the reaction space due to evaporation of some of the middle oil. Such compensation can be provided by recycling some of the asphalt-rich h.o.l.d. (heavy-oil letdown) without passing it through the residue processing stage.

Such sludge recycling (even in the

absence of recycle middle oil) offers certain other advantages, to wit: A better control over the temperature in the converters because of the stabilizing influence of this reaction-refractory slurry; reduction of the danger of drying out and consequent coking in the hot catchpot (this is particularly important in the hydrogenation of tars and oils which leave only little asphaltene bottoms and are subject to quick volatilization due to a comparatively small rise in hot catchpot temperature); reduction of residue processing; certain operational advantages in the preheaters. H.o.l.d recycle has, however, the disadvantage of burdening the converter volume more severely than normal operation in which heavy oil constitutes the bulk of the pasting oil.

II. Temperature

Storch[4] points out that there is probably a fourfold set of reasons why coal hydrogenation in the liquid phase requires temperatures above 750° F.: 1) The fact that active pyrolysis of coal does not occur until such temperatures are reached; 2) the positive temperature coefficient of hydrogen in most liquids; 3) the decrease in retardation of the reaction rate at high temperatures due to decreased absorption of bituminous materials on the catalyst, and 4) the effect of temperature and particle size on the rate of depolymerization and solution of the coal substance. A fifth reason is probably the positive temperature coefficient of the diffusional processes which take place.

Gordon[5] has determined the effect of temperature on product distribution. The results, which are based on autoclave experiments with fixed contact time and pressure, have been reproduced in Figure 1. It will be seen that operation at higher temperatures results in the displacement of the product spectrum toward the lighter hydrocarbon range. Further data by Gordon indicate that a longer contact time at any one temperature is equivalent to the use of a higher temperature.

In industrial practice, the operating temperature is in effect limited between 860° and 920° F. These limits are determined by the need for high space performance, conversion, and asphalt decomposition on the one hand, and by the desire to keep coke and gas formation at a minimum.

The objection to high temperatures is this very tendency to high coke and gas formation which results from the shift of the equilibrium in the direction of dehydrogenation under such conditions. This equilibrium shift can be counteracted by the use of higher hydrogen pressures which permit a boost in temperature.

A temperature rise of 18° F. in the liquid phase results in a boost in reaction velocity of about 50 percent.[3]

III. Pressure

At the high operating temperatures involved in the hydrogenation of carbonaceous matter, there is a strong tendency toward repolymerization of the primary decomposition products to form coke and secondary asphalts which are even more resistant to hydrogenation than the primary asphalts of the material being processed. This tendency can be overcome by the application of high hydrogen pressures. The favorable effect of high-pressure hydrogen is probably due to three fundamental phenomena: 1) The higher solubility of hydrogen at high pressures—it has already been pointed out that the hydrogenating action of *gaseous* hydrogen is only of minor significance. 2) The shift of the equilibrium toward hydrogenating conditions. The more highly saturated compounds which predominate under such conditions can be split more favorably than highly aromatic products. 3) A corollary of the second factor is the favorable effect which can be derived from the presence of large amounts of hydroaromatic compounds formed under strongly hydrogenating conditions. Such compounds are in themselves capable of acting as hydrogen carriers as can be seen from processes such as the Pott-Broche extraction (q.v.) which break down the coal structure with simultaneous hydrogenation in the absence of gaseous hydrogen.

It has been amply demonstrated that liquid-phase hydrogenation cannot be effectively carried out below 3000 psi. hydrogen pressure. Normal industrial operating pressure for oils and some of the younger coals is 4400 psi.

Attempts to hydrogenate bituminous coals and tars high in asphalts and bitumens at 4400 psi. were not industrially successful. It has, however, become possible to liquefy such materials with satisfactory conversion, space performance, and gas formation by increasing the hydrogen pressure sufficiently. The industrial standard pressure selected for these more difficult liquid-phase hydrogenations is 10,300 psi.

By increasing the hydrogen pressure, it becomes possible to raise the reaction temperature. As a result, less active (and cheaper) catalysts can be employed at the same time that considerable advantages in yield and throughput are obtained.

The very important effect of hydrogen pressure is strikingly demonstrated by the following results obtained in the hydrogenation of a Ruhr coal of 82.7 percent carbon content:[6]

A typical industrial bituminous coal throughput through the liquid phase at 10,300 psi. is 1.2 tons per hour per hundred cubic feet reactor volume. At 4400 psi., the throughput is closer to 0.8. It should be noted, however, that, due to mechanical difficulties, 10,300 psi. converters are generally built with a considerably smaller reaction volume than the reactors for the lower pressure. The throughput per converter, or per ton of steel in existing plants is therefore not significantly higher at 10,300 psi than at 4400 psi.

PRESSURE	4,400 psi.	10,300 psi.	10,300 psi.
Catalyst	Tin-chlorine	Tin-chlorine	Iron
Reaction temperature, °F.	868	882—895	886—895
Conversion, percent	93	97	96
Space performance (lbs. oil per hour per cu. ft.)	11.3	20.0	16.9
Percent Gas formation	25	19	21
Asphalt content of h.o.l.d. (Percent referred to pure coal)	18	9	11

IV. Throughput

The effect of increasing the contact time in the liquid phase is practically identical with the effect obtained by raising the temperature. A plot of "Yield of Products" vs. "Reaction Time" has been obtained by Gordon.[5] In appearance, it is almost identical to Figure 1, except that the abscissa "temperature" now reads "reaction time."

Under standard operating conditions, the hold-up time in industrial liquid-phase converters is about 1-2 hours.

By reducing the reaction time (i.e. boosting the throughput), while keeping the other process variables constant, it becomes possible to produce heavier oils than are normally obtained—or even desired. One German plant (Blechhammer) manufactured heavy fuel oils and gasoline in about equal amounts by operating at abnormally high throughput rates and removing a large portion of the "extra" heavy oil for sales. The middle oil from the liquid phase was converted to gasoline in the normal manner.

Throughput rates at Blechhammer were 2.0 tons coal per hour per 100 cubic feet instead of the normal 1.2 tons (bituminous coal, 10,300 psi.)

By raising throughput rates even more, it is possible to obtain a filterable product consisting predominantly of bitumens of high molecular weight. This process—"extractive hydrogenation"—and its possible application as a first step in standard hydrogenation will be discussed in a later article of the present series.

It is obvious that the production of heavy fuels requires a much lower hydrogen consumption than gasoline manufacture from the same raw material. In view of the resulting savings and of the increased amounts of materials which can be handled at the high throughput rates, it has been variously suggested that the manufacture of heavy oils should be looked upon as one of the main tasks of coal hydrogenation in an integrated American synthetic fuels program.

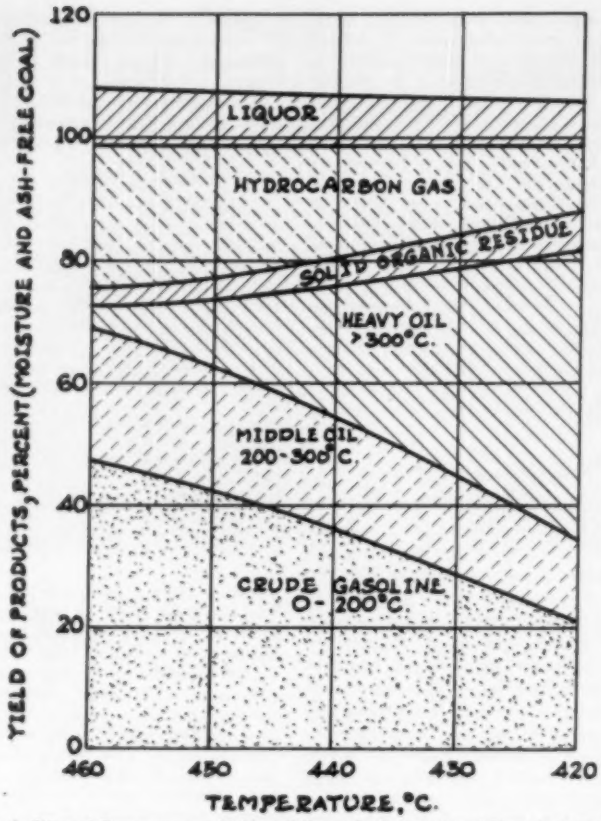


Figure 1. Effect of Temperature on Yield of Different Products in Liquid-Phase Hydrogenation of Coal.

Products of the Liquid Phase

The normal function of the liquid phase in high-pressure hydrogenation is the production of maximum amounts of middle oil boiling between 355° and 620° F. At the same time, appreciable quantities of gasoline and gaseous hydrocarbons are formed along with the primary usable products of the liquid phase—the heavy oils.

Perhaps the most striking aspect of the products of the liquid phase is the very pronounced imprint of the raw material which they bear. The reason for this close analogy between raw material and hydrogenation product is found in the very dilute catalytic conditions which prevail in the liquid phase. The catalyst is present in sufficient concentration to carry out its prime function—to hasten the hydrogenation and breakdown of asphalts, but its great dilution prevents it from exerting an effective influence on the class of compounds which the process may yield.

The similarity between raw material and product has been illustrated strikingly by data due to Pier:[7]

Middle Oil: 355-620° F.	Specific Gravity at 15° C.	Aniline Point °C.	Aniline Point of the Fractions 210-320°	240-270°	280-310° C.
I. Straight Run Distillate from Mixed Base Crude Oil	.840	61	56	59	66
Liquid Phase Hydrogenation Distillate from same oil	.838	57	52	56	61
II. Straight Run Distillate from Asphalt Base Crude Oil	.856	50	47	50	54
Liquid Phase Hydrogenation Distillate from same oil	.851	51	49	52	54

It will be noted that the aniline points (indicating the degree of aromaticity) of the corresponding fractions of the straight-run distillate and of the liquid-phase hydrogenation product are very similar. This rule, according to Pier, is so general that the properties of the liquid-phase middle oil can be predicted with great precision from the properties of the straight-run middle oil.

A similar, though less striking correlation exists between the tars obtained by low-temperature carbonization of coals and the products obtained by the hydrogenation of the same solid raw material.

The influence of raw material on the liquid phase product is also illustrated effectively by the octane number of gasolines obtained from the liquid phase of various raw materials:[7]

Raw Material	O.N. of Liquid-Phase Gasoline (Research Method)
Mixed base petroleum residue	53
Asphalt Base Petroleum residue	57
Asphalt Base Gas Oil Cracking residue	73

This comparison shows that a higher-grade liquid-phase gasoline is obtained by the hydrogenation of more aromatic stocks.

The gases obtained in the course of hydrogenation contain some carbon oxides—formed as a product of the refining reactions of the liquid phase—and some nitrogen and hydrogen sulfide. Almost the entire remainder are saturated paraffinic L.P. gases. A typical gaseous hydrocarbon distribution has been reported for industrial operation of a bituminous coal hydrogenation plant:[3]

CH_4	26	weight percent
C_2H_6	24	weight percent
C_3H_8	32	weight percent
C_4H_{10}	14-18	weight percent

(10-25 percent of the total butanes is isobutane)

TABLE 1. Yield of Useful Phenols Formed During the Hydrogenation of Various Raw Materials

Raw Material	Lignite Tar	Low Temperature Carbonization Tar from Bituminous Coal	Bituminous Coal Tar (Topped)	Lignite Lausitz	BITUMINOUS COAL		
					UPPER SILESIA		Gelsenberg
Conditions of Operation	Gas. + Middle Oil	Heavy Oil	Heavy Oil	Gas. + Middle Oil	Gas. + Middle Oil	Heavy Oil	Gas. + Middle Oil
Pressure (Atmospheres)	600	600	600	250	600	600	600
Phenols (based on oil yields)—percent	7.10	4.23	4.14	3.96	8.20	6.63	6.82
Carbolic Acid (based on gasoline and middle oil in the new oil)—percent	0.77	2.19	1.74	1.31	2.60	3.64	1.37
O-Cresol (based on gasoline and middle oil in the new oil)—percent	0.80	0.39	0.54	0.70	0.78	0.95	1.05
P-m-Cresol (based on gasoline and middle oil in the new oil)—percent	2.06	2.83	1.34	1.50	2.67	3.83	2.43
Xylenols (based on gasoline and middle oil in the new oil)—percent	3.47	2.43	1.72	0.45	2.15	3.63	1.97
Total—percent	7.10	7.84	6.33	3.96	8.20	12.05	6.82
Phenols (based on raw material)—percent	5.95	3.43	3.18	2.62	4.92	4.44	4.45

The distribution of hydrocarbon gases is surprisingly independent of raw material and operating conditions employed. The quantity of gaseous products is, on the other hand, significantly influenced by operating conditions—mild operation tends to minimize the formation of hydrocarbon gases.

The bulk of the liquid-phase oils are of an aromatic and naphthenic character. The composition of a low-boiling neutral oil from liquid-phase hydrogenation of Pittsburgh seam coal has been reported by Storch:[4]

Constituent	Volume Percent of 20° to 210° C. Fraction
Benzene	1.5
Toluene	2.1
Xylene	6.3
Cyclohexane and Methylcyclohexane	6.1
Dimethylcyclohexane	4.5
Tetrahydronaphthalene	13.9
Polyalkylbenzenes	65.6

Woolfolk and co-workers identified the following compounds in the 385°-450° C. fraction of a Pittsburgh bed coal liquefaction product:[8] Tetralin, alkylated naphthalenes, anthracene, phenanthrene, pyrene.

From a by-product point of view, the hydrocarbons contained in the asphalt derived from coal liquefaction represent chemicals of potential value. These materials are composed of two main classes:[3]

1) Highly condensed aromatics (including heterocyclics with O, H, S in the ring)
   a) in dehydrogenated form
   b) in partially hydrogenated form
2) Reaction products from labile, partially hydrogenated, highly condensed aromatics.

Representative of these compounds are such materials as coronene, dibenzcoronene, carbazol, pyrene, etc. These materials are found in hydrogenation h.o.l.d in about the following ratios:

Carbazol: Pyrene 1:10
Pyrene: Methylpyrene: Dimethylpyrene 10:2:0.8
Pyrene: Coronene 10:1 to 20:1

It has been estimated that the following amounts of coronene are potentially recoverable from the liquefaction products of various raw materials:

From bituminous coal
70 tons per 100,000 tons coal
lignite
15 tons per 100,000 tons coal
petroleum cracking residue
25 tons per 100,000 tons oil

Tar Acids and Bases

Most of the raw materials for high-pressure hydrogenations are rich in secondary elements—oxygen, nitrogen, and sulfur. One of the essential functions of the liquid phase is to exert a refining action by the reaction of hydrogen with these elements to form ammonia, hydrogen sulfide, and water. The refining efficiency of the liquid phase is, however, not very high, and some 20 percent of the initial oxygen and sulfur, and about one-half of the initial nitrogen is found in the oil products.

Most of the oxygen in the product oils is present in the hydroxyl group of phenolic compounds. In normal operation, these compounds (except for the water-soluble portion) are reduced in the vapor phase to form their parent hydrocarbon. The commercial recovery of such tar acids from the middle (and heavy) oils of the liquid phase has, however, potential significance and their sale might pay a sizable part of operating costs in some of the first hydrogenation plants to be constructed in the United States.

The bulk of the tar acids present in high-pressure hydrogenation are the lower members of the homologous family: phenol, cresols and xylenols. Data establishing this fact have been reported by Heyn and Dunkel for the hydrogenation product of a German coal.[9] More recently, Storch has reported the tar acids found in the hydrogenation product of a Pittsburgh seam coal:[4]

	Percentage of Total Tar Acids
Phenol	8
Cresols	27
Xylenols	30
Higher phenols	35
	100

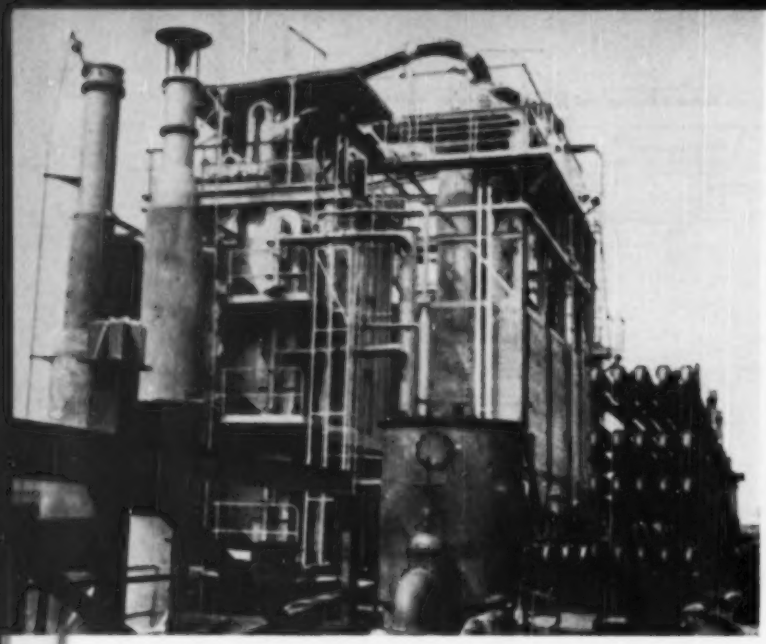
Table 1 illustrates the phenols obtained in the normal liquid-phase hydrogenation of various raw materials. The data, obtained at German hydrogenation works, are reported by Sherwood.[3] It will be seen that bituminous coal yields an oil particularly rich in phenols, and that low-temperature carbonization tars yield more phenols than can be obtained in the hydrogenation of high-temperature tars.

As a rough rule, one ton of bituminous coal will yield 30 pounds phenol and 70 pounds cresols plus xylenols. The mixture of cresols and xylenols has a high inhibiting effect on the leaded gasoline produced by high-pressure hydrogenation and can be employed to good advantage in concentrations of about 0.01 percent.

The tar bases constitute secondary products of minor importance. Pyridine has been reported[10] to be present in concentrations of about .012-.017 in the liquid phase gasoline fraction (up to 165° C.) The higher pyridine concentration of .04-.06 percent which was found in the middle oil fraction has been explained by the formation of phenol-pyridine addition compounds which boil in the middle oil range.

Heyn and Dunkel's work[9] has demonstrated that the bulk of the nitrogen bases are present in the heavy fractions of the liquefaction oils. No attempt has been made to make a complete study of these tar bases of high molecular weight.

Liquid-phase gasoline contains some other recoverable chemicals. This fraction of the liquefaction product at the Leuna hydrogenation works contained 1.0-2.5 percent acetone, about the same amount of methyl ethyl ketone, and .2 percent acetonitrile.[5] These materi-



Side View of Liquid-Phase Hydrogenation Stall.

als were recovered industrially by aqueous extraction followed by azeotropic distillation.

Recovery of Tar Acids

The phenolic compounds found in the products of the liquid phase constitute a potential source of revenue. Hirst and co-workers[11] estimate that a credit of 5.0 cents per gallon of gasoline will accrue from the sale of such by-product tar acids. If the technical problems involved in the recovery of phenols are solved satisfactorily, the first hydrogenation plants might indeed derive considerable benefit from this operation. Later plants cannot safely count on the existence of an adequate market for these materials. One 20,000 barrel per day bituminous coal hydrogenation plant can be made to yield some 150 million pounds per year tar acids, just as a chemical by-product. In 1945, the daily refinery output of the United States was 2.1 million barrels gasoline; 224 million pounds of tar acids were produced in the course of the same year.

A portion of the tar acids is found in the aqueous phase associated with the liquefaction products in the cold catchpot. Recovery from these waste waters has been accomplished commercially by extraction methods derived from the coal tar industry. The preferred solvents were tricresyl phosphate, and, in more recent years "Phenosolvan" (butyl acetate) which has the advantage of being a low-boiling, distillable chemical which can be recovered effectively without the accumulation of impurities.

As far as the writer knows, the hydrogenation plant at Billingham, England, is the only one where tar acid recovery from hydrogenation oils was ever actually attempted.[12] The recovery was effected by subjecting a suitable naphtha cut to a caustic soda wash to extract sodium phenates which are highly water-soluble. The tar acids are then sprung by the introduction of carbon dioxide. The phenolic oils settle out and are separated. Final purification is carried out by distillation. The Billingham plant for the recovery of tar acids was constructed in 1937 when the plant was devoted to the hydrogenation of coal, and the oil products of the liquid phase contained up to 2.2 percent phenol and 6.5 percent cresol. Since that time, coal has ceased to be the raw material and the phenols obtained from creosote oil hydrogenation are insufficient to justify continued operation of the recovery plant.

Bemmann[13] has considered the methods most highly suited for the recovery of tar acids from liquid-phase oils. His attention was concentrated on three processes: 1) The hot water process, 2) the sodium sulfide process, 3) the counter-current sodium hydroxide process.

In the first of these processes, the oil is extracted with water at 430° F. and 750 psi., using a water-to-oil ratio of 2:1. The success of the process depends on the efficiency of heat recovery. The purity of the product phenols leaves much to be desired, because water at these elevated temperatures is not adequately selective and tends to dissolve neutral oils together with the phenols.

The sodium sulfide process yields a product of high purity and in good yield. The phenols are extracted with sodium sulfide at 212° F. The dissolved tar acids are sprung by treatment of the extract solution with hydrogen sulfide at 120° F. The caustic solution can be recycled while the phenol layer is distilled. This process has the disadvantages of operating with toxic hydrogen sulfide and of requiring special materials of construction, resistant to the corrosive action of hot sulfide solution.

The third method, counter-current sodium hydroxide extraction, has already been mentioned in connection with phenol-recovery operations at Billingham. The spent sodium carbonate solution can be revivified by recausticizing with lime. The operation is carried out at normal temperatures and pressures. The extraction of neutral oil together with the desired phenols is negligible as long as the sodium hydroxide concentration is maintained below ten percent. No serious corrosion troubles are encountered. The counter-current sodium hydroxide extraction process has the additional advantage of solutizing the low-boiling, stronger-acid phenols preferentially, i.e. the tar acids which have the greatest commercial interest.

Hirst and co-workers[14] visualize the extraction of tar acids from hydrogenation oils by means of methanol. Since some neutral oil is extracted in the course of this procedure, it is necessary to wash the extract with naphtha before removing the methanol solvent from the extracted tar acids.

* * *

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Sugar cane, which has been cut in the field, is hauled to the mill by train and truck where giant cranes feed it to the grinders. The juice is pressed out, boiled and made into syrup.

(This and other photos in this article used through courtesy of State Department of Commerce and Industry, Baton Rouge, La.)

Petroleum-Type Hydrocarbons From Sugar Cane

HEINZ HEINEMANN

Houdry Process Corporation, Marcus Hook, Pa.

THE procedure followed in converting sugar cane to hydrocarbons is basically the same as that used in the conversion of cellulose, potatoes, leaves, etc.[1, 2, 4, 5] Sugar cane is incoalified in the presence of aqueous alkali solution by heating in a closed autoclave to a maximum temperature of 750° F. The influence of pH and type of alkali used, on product nature and distribution is the same as that observed for other carbohydrates.[1] The more alkali is present, the less coal and the more bituminous product (proto-product) is formed.

During incoalification, an intramolecular combustion forms bitumen, carbon dioxide, water, methane, acids (phenols and phenol carboxylic acids) and coal. This intramolecular combustion is a kind of Canizzaro reaction. Some of the aldehyde carbohydrates disproportionate into carbonic acids, water and oxygen-free hydrocarbons.

From the bitumen it is possible to obtain by vacuum distillation an asphalt which closely resembles natural asphaltic materials such as Trinidad asphalt.

Hydrogenation of the bitumen in the presence of molybdena-type catalysts results in a hydrogenated bitumen which can be extracted with organic solvents such as carbon tetrachloride. This extract gives on distillation hydrocarbon fractions boiling in the gasoline, middle oil and lubricating oil range and a residual asphalt which can be further hydrogenated.

The gasoline can be reformed to a product of satisfactory anti-knock characteristics, while the middle oil fraction can be catalytically cracked to yield additional gasoline, hydrocarbon gases suitable for polymerization and alkylation and recycle stock. Small amounts of oxygen in the virgin lubricating oil fraction can be removed by further hydrogenation with a Raney nickel catalyst.

***THE CONVERSION** of carbohydrates to hydrocarbons has been studied over a long period of time by E. Berl and coworkers and has been discussed in numerous publications.[1, 2, 3, 4, 5] Dr. Heinemann's present article is concerned with one phase of this problem, namely the conversion of sugar cane to petroleum-type hydrocarbons and with an evaluation of these hydrocarbons. This study was initiated and largely carried out under the guidance of the late Dr. Ernst Berl.*

It is thus possible to convert about 33 percent of the dry substance of sugar cane into petroleum-type hydrocarbons, and about 10 percent to gasoline and 7 percent to lubricating oil. These materials appear to be largely formed from the saccharose, hemicellulose and cellulose content of the sugar cane, while the lignin is converted to the asphaltic materials found in the hydrogenated bitumen, all of which materials are high in methoxyl content.

An Aminco shaking type hydrogenation bomb was used for incoalification and hydrogenation of the sugar cane. The sugar cane, cut into cubes of about 1 inch, was placed into the bomb with enough aqueous sodium hydroxide to give about 750 cc. 1-N NaOH/100 g. dry substance. The mixture was heated in the closed bomb first for five hours at 250° F., then for five hours at 625° F. The bomb was then vented and carbon dioxide and methane were collected for analysis. Bitumen and water were separated, and carbon dioxide and acids contained in the water were determined.

The bitumen was hydrogenated in the Aminco bomb in the presence of molybdenum oxide or sulfide catalysts at 750° F. and with an initial hydrogen pressure of 1000 psig. The hydrogenation was repeated until no more hydrogen was consumed.

The hydrogenated product was extracted with carbon tetrachloride and

the extract subjected to distillation at atmospheric and subsequently at reduced pressure.

Reforming of the gasoline fraction was carried out by passing gasoline vapors at 1000° F. and atmospheric pressure over a synthetic silica-alumina catalyst (Socony-Vacuum Oil Company beads) at a liquid space velocity of 3 volumes per volume per hour and a catalyst to oil ratio of 1.

Cracking of the middle oil fraction was over a synthetic silica-alumina catalyst (Socony-Vacuum Oil Company beads) at 825° F., atmospheric pressure, at a liquid space velocity of 1.25 volumes per volume per hour and a catalyst to oil ratio of 1.

Hydrogenation of the lubricating oil fraction in the presence of Raney nickel was carried out at 45 psig. and 150° F.

Carbon dioxide and methane in gas were determined by Orsat analysis. Carbon and hydrogen analyses were by a semi-micro method.[6]

Methoxyl contents were determined by Zeisel's method.[7]

Acids in the water from incoalification were determined by titration with sodium hydroxide, after removal of carbon dioxide.

Analysis of the sugar cane was carried out as follows: a sample of sugar cane was extracted by boiling with toluene to determine water according to the Dean method.[8] Simultaneously another sample was repeatedly extracted with water and subsequently extracted with toluene. The samples were freed from toluene in the vacuum, dried and weighed. The difference between the weight of the two samples was equal to the saccharose content. The residue was boiled with 4 percent sulfuric acid which was decanted and renewed every hour, until Fehling solution gave a negative test. The residue thus obtained was washed with water, extracted with toluene, dried in vacuuo and weighed. Weight loss was equal to hemi-cellulose. The remaining residue was then boiled repeatedly with 72 percent sulfuric acid until Fehling solution gave a negative test, washing, toluene extraction and drying were repeated, weight loss being equal to cellulose. The final residue was lignin and was tested for its methoxyl content.

Testing of the hydrocarbons was by

TABLE 1

Comparison of Natural and Synthetic Asphalt

	Natural Asphalt (1)	Synthetic Asphalt
Appearance	brown-black to glossy black	glossy black
Hardness (Mohs)	1—3	2
Softening Point, °C.	30-90	70
Specific Gravity	1.05-1.30	1.216
Solubility	v.s. CS_2, CCl_4 C_6H_6 sl.s. acetone, ether	v.s. CS_2 sl.s. acetone, ether
Elementary Analysis:		
Percent C	86.0	90.1
Percent H	9.0	7.6
Percent O	4.0	2.3
Percent S	0.8	0
Percent N	0.2	0
Fluorescence	In acetone: brown-green	In acetone: green

TABLE 2

Gasolines from Sugar Cane

	Gasoline Fig. 1, No. 14	Reformed Gasoline Fig. 1, No. 14	Cracked Gasoline on Middle Oil Fig. 1, No. 15
Boiling Range, °F.:			
IBP	90	95	99
10 percent	105	111	120
50 percent	254	249	271
90 percent	378	380	379
E.P.	400	400	400
Color, Saybolt	30+	30+	30
Olefins, percent	9	39	42
Aromatics, percent	12	18	25
Naphthenes, percent	9	6	6
Paraffins, percent	70	37	27
Octane Number	35	68	72

TABLE 3

Gas Composition, Mole %

	Reforming of Gasoline	Cracking of Middle Oil
Methane	11	5
Ethane	4	7
Ethylene	9	9
Propane	10	8
Propylene	13	15
n-Butane	9	4
i-Butane	23	19
Butylenes	19	30
C_5 and heavier	2	3

Sugar Cane Standing in Louisiana Field.

Here's how Louisiana growers plant their huge fields of sugar cane.

conventional methods, such as ASTM distillation of gasoline to a 400° F. end point (ASTM D86-46), gasoline analysis by the method of Faragher, Morrell and Levine,[8] viscosity determinations and CFR motor method octane number test (ASTM D357-46).

Experimental Results and Discussion

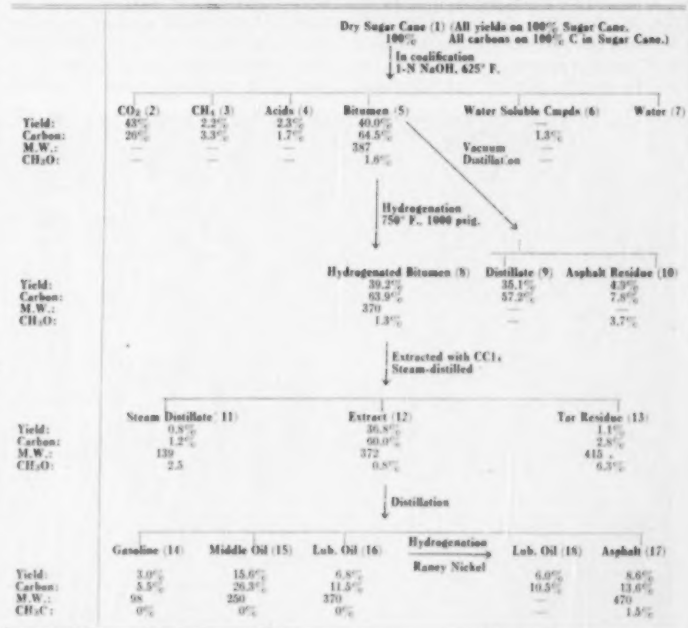
Yields and Carbon Distribution

Results obtained in the incoalification and hydrogenation of a Louisiana sugar cane are summarized in Figure 1. The data are representative of a considerable number of runs made and vary slightly from run to run. Maximum deviation observed was ±2 percent. Yields are given in percent of dry, water-free sugar cane and the carbon balance is based on carbon in the sugar cane. Methoxyl contents given are based on the particular sample which was subjected to analysis. The sugar cane contained 15.25 percent saccharose, 27.8 percent hemicellulose, 22 percent cellulose and 35 percent lignin. Its carbon content was 49 percent C and the methoxyl content of the lignin fraction was 4.9 percent CH_3O.

It appears that most of the lignin residues still present after incoalification in the bitumen (Figure 1, No. 5) are eventually found in the asphaltic fractions (Figure 1, No. 13 and No. 17) and the hydrogenated steam distillate (Figure 1, No. 11), and that most of the lighter hydrocarbons (Fig-

FIGURE 1

Yields and Carbon Balances for the Conversion of Sugar Cane


Dry Sugar Cane (1) (All yields on 100% Sugar Cane. 100% All carbons on 100% C in Sugar Cane.)
In coalification 1-N NaOH, 625° F.
CO2 (2)
CH4 (3)
Acids (4)
Bitumen (5)
Water Soluble Cmpds (6)
Water (7)
Yield: 43% 2.2% 2.3% 40.0% — —
Carbon: 20% 3.3% 1.7% 64.5% 1.3% —
M.W.: — — — 387 — —
CH3O: — — — 1.8% — —
Vacuum Distillation
Hydrogenation 750° F., 1000 psig.
Hydrogenated Bitumen (8)
Distillate (9)
Asphalt Residue (10)
Yield: 39.2% 35.1% 4.9%
Carbon: 63.9% 57.2% 7.8%
M.W.: 370 — —
CH3O: 1.3% — 3.7%
Extracted with CCl4 Steam-distilled
Steam Distillate (11)
Extract (12)
Tar Residue (13)
Yield: 0.8% 36.8% 1.1%
Carbon: 1.2% 60.0% 2.8%
M.W.: 139 372 415
CH3O: 2.5 0.8% 6.3%
Distillation
Gasoline (14)
Middle Oil (15)
Lub. Oil (16)
Hydrogenation Raney Nickel
Lub. Oil (18)
Asphalt (17)
Yield: 3.0% 15.6% 6.8% 6.0% 8.6%
Carbon: 5.5% 26.3% 11.5% 10.5% 13.6%
M.W.: 98 250 370 — 470
CH3C: 0% 0% 0% — 1.5%

ure 1, Nos. 14-16) are derived from saccharose, hemi-cellulose and cellulose.

Asphalt

Asphalt contained in the bitumen and obtainable by distillation (Figure 1, No. 10) is similar to natural asphalts such as Trinidad asphalt. A comparison of the two materials is given in Table 1. The major difference lies in the solubilities of the two asphalts.

Petroleum-Type Hydrocarbons

The gasoline obtained by distillation from the hydrogenated bitumen extract (Figure 1, No. 14) is a highly paraffinic product. It is low in olefins and contains some aromatics and naphthenes. The product has a low octane number and strongly resembles some straight-run gasolines from petroleum (Table 2).

Catalytic reforming of this gasoline at 1000° F. increased the olefin and aromatic content and raised the octane number (Table 2). Due to the limited amounts of this product available, only a few reforming experiments could be carried out and it cannot be assumed that optimum conditions were established. Yields on reforming were 91 weight percent liquid recovery, 8 percent gas and 1 percent coke. Gas composition is given in Table 3.

The middle oil fraction (Figure 1, No. 15) boiled in the range 400-700° F., was yellowish-white and not viscous and in appearance resembled a gas oil. Its specific gravity was 0.857 and it contained 9 percent olefins. A carbon-hydrogen analysis gave 87.7 percent carbon and 10.09 percent hydrogen, or a mole ratio of 1.38.

On catalytic cracking at 825° F., this oil gave 44 percent gasoline, 7 percent gas, 3.7 percent coke and 45.3 percent gas oil recycle stock. Conversion was 54.7 percent. Gasoline characteristics are presented in Table 2, while gas composition is given in Table 3. The gas oil seemed similar to the original middle oil.

The vacuum distilled lubricating oil fraction (Figure 1, No. 16) was a viscous oil of greenish-brown fluorescence and contained 2 percent of oxygen. The oxygenated compounds were destroyed by hydrogenation with Raney nickel. The resulting product (Figure 1, No. 18) had the following characteristics:

Color—brown
Fluorescence: faintly green
Sp. Grav.—0.897
R.I.—1.502 at 20° C.
Visc. at 25° C.—.973 cp.
Visc. at 35° C.—.507 cp.

Influence of Hydrogenation Conditions on Yield

Yield figures of hydrogenated products are dependent on the conditions of hydrogenation of the bitumen (Table 4). Insufficient amounts of products were obtained for evaluation of the various fractions. It appears, however, that more severe hydrogenation conditions increase the yield of lighter products. The asphaltic residues formed, on the other hand, while smaller, become more coal like. Less severe conditions should be used, therefore, if lubricating oils are desired; more severe conditions, if gasoline and gas oil are wanted.

Summary

Sugar cane is subjected to an internal combustion by heating in the presence of alkali under pressure. The resultant bituminous material can be hydrogenated to a product which upon fractionation yields a gasoline, a middle oil and a lubricating oil fraction, as well as asphalt. The gasoline can be reformed and the middle oil catalytically cracked to give gasoline of satisfactory octane rating. Yields of petroleum-type products can be directed either to lighter or to heavier fractions by adjustment of the hydrogenation conditions.

TABLE 4
Hydrogenation of Bitumen

Temperature, °F.	750	750	850
Initial H_2 Pressure, psig.	800	1000	1000
CCl_4 extract, Wt. % of bitumen	92.0	93.7	95.2
CCl_4 residue, Wt. % of bitumen	4.4	2.8	1.4
Gasoline, Wt. % of bitumen	6.2	7.7	10.1
Middle oil, Wt. % of bitumen	34.7	39.1	44.2
Lubricating Oil, Wt. % of bitumen	20.0	17.6	14.8
Asphalt, Wt. % of bitumen	24.8	21.0	16.9

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ACKNOWLEDGMENT

All photographs were furnished by and used through courtesy of W. E. Anderson, Commissioner, Louisiana Department of Agriculture and Immigration, Baton Rouge, La.

Closeup View of Sugar Cane Growing in Louisiana Field.

***THE AUTHOR** comments that when he started in business in 1910, rotary pumps were unimportant in industry. Oil and sugar refineries, and similar large users, depended on reciprocating steam pumps with an occasional triplex power pump.*

Just as the scientifically designed centrifugal pump made an increasingly large place for itself handling water and light materials, so has the rotary pump, which is no longer the light, cheap unit of 1910, taken its place handling more viscous materials.

Now we not only pump tar, heavy fuel and lubricating oils, glucose and molasses at temperatures that were believed impossible 40 years ago, but also asphalt, wood rosin, cellulose acetate, plastics, loaded coating asphalt, commercial white lead and many other products that were not pumped at all then. In fact, many of the materials were not even in existence and others had so little commercial use that methods of handling them were relatively unimportant.

This article is based upon a paper presented before the First Pan American Engineering Congress, at Rio de Janeiro, in July, 1949. It will be noted that certain of the examples are concerned with molasses or other non-petroleum products. These materials, however, have close counterparts in the refineries, in so far as their handling by pumps is concerned, and ideas used in sugar refineries or asphalt roofing plants may have high value in the handling of petroleum greases or oil slurries.

Pumping Viscous Materials

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Vice President, Kinney Manufacturing Company, Boston

FROM experience in applying rotary pumps to installations involving viscous materials, much has been learned that can be passed along to others who have similar problems. Not until about 1920 was there any dependable information on the relation of viscosity and density of liquids to pipe friction loss. There is still a range where the flow in the pipe may be either turbulent or laminar, in which there is some uncertainty. For practical purposes, this can be disregarded, since almost all of the highly viscous materials are in laminar flow and the wild guesses formerly necessary as to the proper pipe sizes and power requirements are now replaced with mathematical solutions. Mathematical solution, however, is based on knowledge regarding the viscosity and density of the liquid at pumping temperature. It pays big dividends to acquire this information prior to designing the system rather than guessing and regretting it later.

Viscosities of most petroleum products are now available from the producers. Commercial laboratories can readily obtain the data from samples on many other products. Some, molasses for instance, are more of a problem because of extreme lack of uniformity. Sugar refineries, alcohol distillers, and cattle feeders are all interested in the sugar content of molasses which is indicated by the Brix. Unfortunately, there is no relation between Brix and viscosity in black strap molasses.[1] The viscosity is dependent on the resin content which varies with several factors.

Figure 1 shows some tests on molasses and glucose from various sources. Note not only wide variation in viscosity at a given temperature, but also the rapid change of viscosity with change in temperature; so care should be made to use the data for the approximate temperature that will exist under working conditions.

Extensive tables for friction losses have been published from time to time, one of the latest being the Pipe Friction Section of the Standards of the Hydraulic Institute.[2] For those who do not have such material available, this formula will prove accurate within reasonable limits with laminar flow and clean smooth pipe:

$$P = \frac{27.3 \times \mu \times Q}{d^4} \quad \text{in which (3)}$$

P = pressure loss in pounds per square inch per 1000 feet of pipe
μ = absolute viscosity expressed in poises (Stokes × SG)
SG = specific gravity or density of the fluid
Q = quantity in U. S. gallons (231 cubic inches)
d = actual inside diameter of pipe in inches

For series 40 steel pipe, the values of d^4 are shown in Table 1.

TABLE 1

Nominal Size	Actual Diam.	d^4	Nominal Size	Actual Diam.	d^4
1"	1.049	1.21	6"	6.065	1353.07
1¼"	1.610	6.71	8"	7.981	4057.22
2"	2.067	18.25	10"	10.020	10080.24
3"	3.068	88.59	12"	11.938	20310.76
4"	4.026	262.72	14"	13.126	29684.49

While this pipe friction formula is used mostly for computing pressure loss it is well to note that obviously it can be solved for viscosity if the pressure is known.

In many cases involving viscous materials, the design engineer does not know the viscosity nor are there laboratories convenient for making tests. Some materials have such high viscosity that commercial types of viscometers require extremely tedious tests and the results are none too accurate.

For example, suppose with a heavy molasses, viscosity unknown, it becomes necessary to determine the proper size pipe to use for shiploading through a long line where considerable investment is involved, and a comparison must be made between a large line and a lower power cost for pumping or a small line and a higher operating cost. A nearby sugar refinery is handling the same grade of molasses from the centrifuge to storage, pumping 30 gallons a minute through 200 feet of 4-inch pipe against 30-foot static head. The resulting pressure is 70 psi., specific gravity of molasses 1.46.

Converting the static head to pounds pressure with correction for gravity: $30 \times .434 \times 1.46 = 19$ pounds. Deducting this from the pressure at the pump, we have 51 pounds pressure loss for 200 feet or 255 pounds for 1000 feet. Substituting this in the pipe friction formula

$$255 = \frac{27.3 \times \mu \times 30}{262.72}$$

$$\mu = 81.79 \text{ poises}$$

Viscosity readings obtained in this manner are often more accurate than

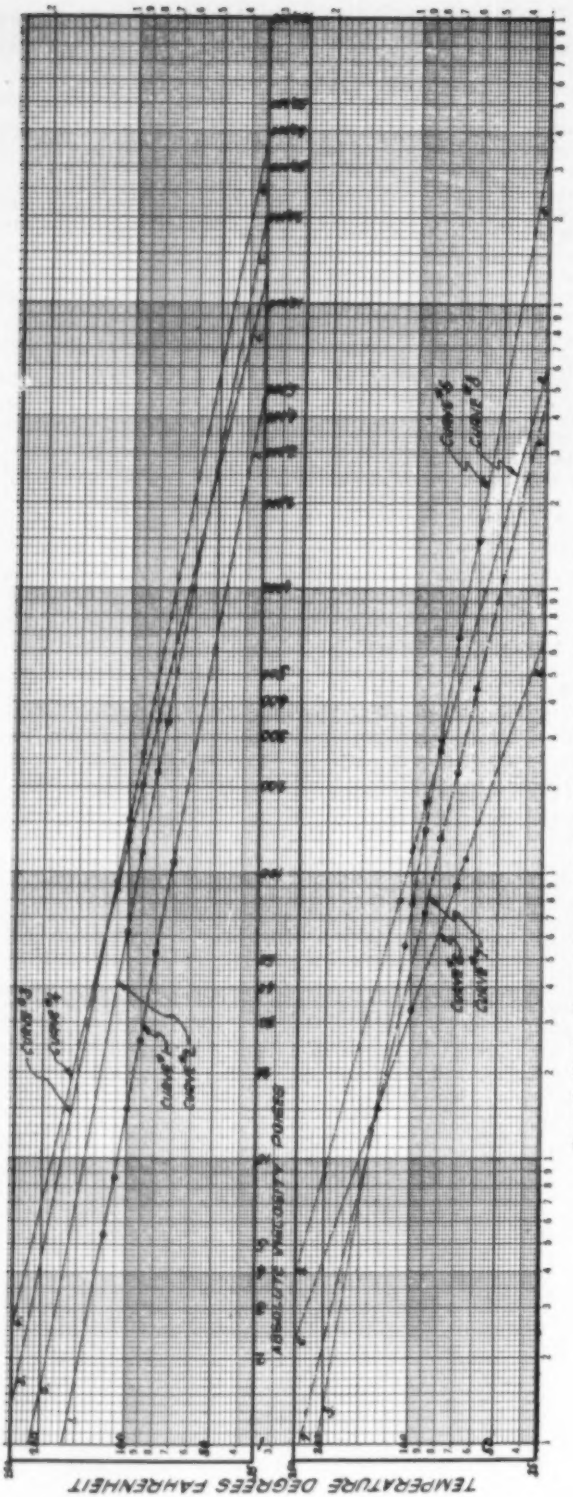


Figure 1. Absolute Viscosity Curves of Molasses, Glucose and Syrup. See Curve references in adjoining Column.

laboratory tests and can be made on the job.

It is well to obtain viscosities for at least two, and preferably for three temperatures. Then, viscosities at other temperatures may be determined with reasonable accuracy by plotting viscosities in poises against temperature in degrees F. on log-log paper. Homogeneous liquids will usually plot in a straight line but caution should be used that the temperature limits are not extended below the melting point or above the temperature at which the liquid flashes to a gas.

In cases of highly viscous materials,

Absolute Viscosity Curves of Molasses, Glucose and Syrup
(From Figure 1)

Temp.	Gravity	S.S.F.	Abs. Vis. Poises	U/G
Curve No. 1 Black Strap Molasses Publicker Commercial Alcohol				
70	1.434	3475	109.7	76.5
80	1.430	1650	52.2	36.5
90	1.426	830	25.9	18.2
100	1.422	500	15.0	1.6
110	1.418	280	8.6	6.1
120	1.414	177	5.4	3.8
Curve No. 2 Black Strap Molasses Publicker Commercial Alcohol				
71	1.384	11200	340	245.8
80	1.380	7400	225	163.—
90	1.379	3850	117	85.5
100	1.376	2080	62	45.7
Curve No. 3 Glucose				
90	1.426	8460	264.9	185.8
100	1.422	4995	150.7	105.—
110	1.418	2945	92.1	65.—
130	1.410	1280	40.1	28.5
Curve No. 4 Syrup from 49/4 Remelt Revere Sugar Co.				
80	1.460	10920	343.1	235
90	1.457	6308	202.5	139
100	1.453	4080	129.3	89
110	1.450	2750	87.—	60
Curve No. 5 High Test Cuban Molasses Pacific Molasses Co. (Keable)				
60	1.348	46750	1476.—	1028
70	1.435	21600	667.2	465
80	1.432	9400	293.5	205
90	1.429	4500	141.4	99
100	1.426	2500	78.—	55
105	1.424	1800	56.2	39.5
Curve No. 6 Hawaiian Cane Molasses Berdans Produce Co.				
55	1.400	3600	110.6	79.
70	1.398	3000	90.1	55.
100	1.389	1125	33.1	24.
130	1.380	500	15.2	11.
Curve No. 7 Peruvian Molasses				
60	1.452	14019	450.	310.
70	1.449	7519	234.	162.
80	1.446	4000	133.	92.
90	1.443	2791	76.6	51.
Curve No. 8 Black Strap Molasses				
80	1.425	8880	270.7	190.
90	1.422	5880	177.7	125.
100	1.418	3800	120.5	85.
110	1.415	2640	80.6	57.

Caution: Note wide variation in absolute viscosity of the products shown. Unless customer guarantees viscosity at pumping temperature, care must be used in applying this data as values plotted where obtained from tests on single samples and not necessarily typical.

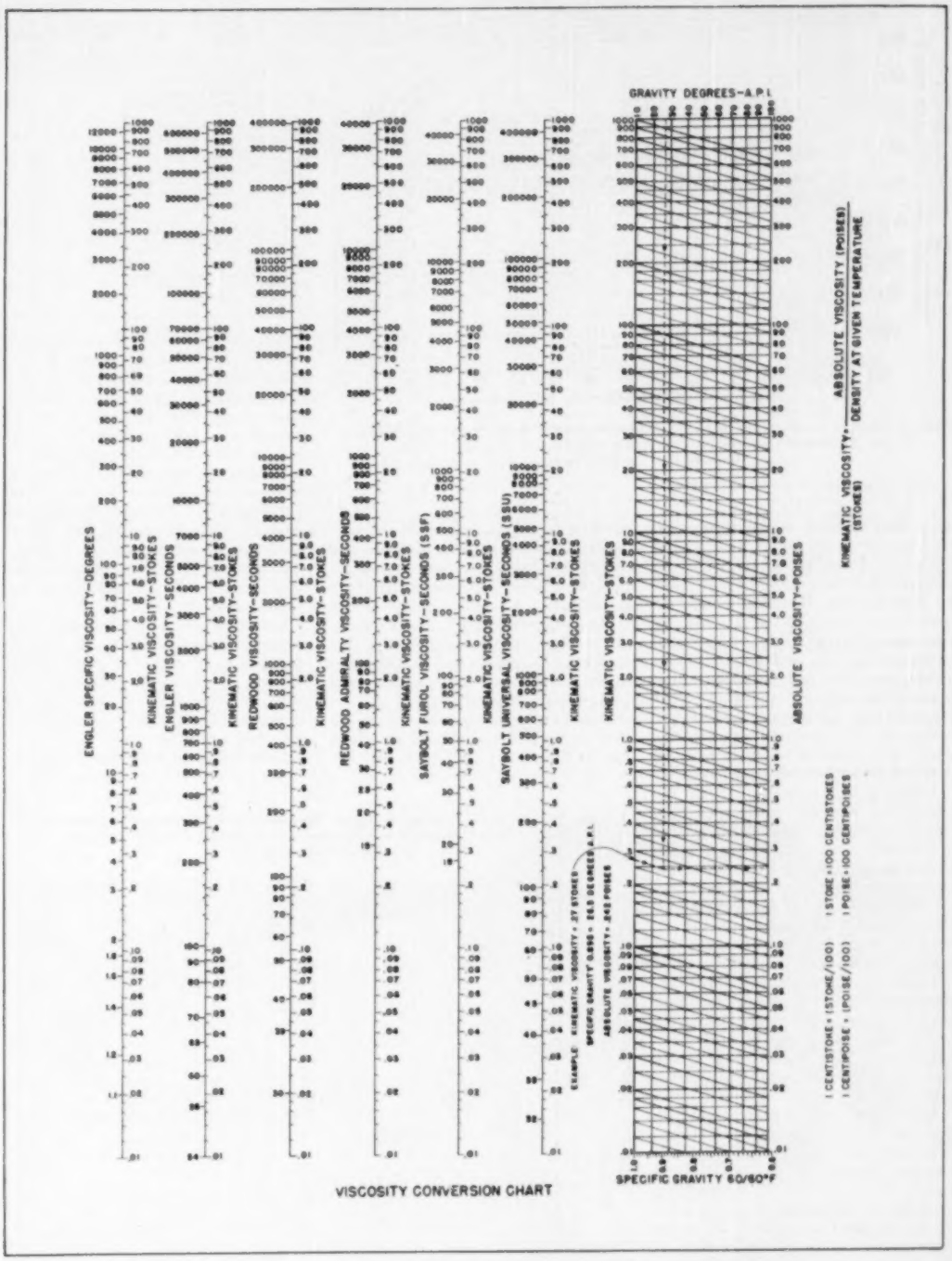

ENGLER SPECIFIC VISCOSITY-DEGREES
KINEMATIC VISCOSITY-STOKES
ENGLER VISCOSITY-SECONDS
KINEMATIC VISCOSITY-STOKES
REDWOOD VISCOSITY-SECONDS
KINEMATIC VISCOSITY-STOKES
REDWOOD ADMIRALTY VISCOSITY-SECONDS
KINEMATIC VISCOSITY-STOKES
SAYBOLT FUROL VISCOSITY-SECONDS (SSF)
KINEMATIC VISCOSITY-STOKES
SAYBOLT UNIVERSAL VISCOSITY-SECONDS (SSU)
KINEMATIC VISCOSITY-STOKES
GRAVITY DEGREES-A.P.I.
KINEMATIC VISCOSITY-STOKES
ABSOLUTE VISCOSITY-POISES
KINEMATIC VISCOSITY (STOKES) = ABSOLUTE VISCOSITY (POISES) / DENSITY AT GIVEN TEMPERATURE
EXAMPLE KINEMATIC VISCOSITY = 27 STOKES
SPECIFIC GRAVITY 0.898 = 26.5 DEGREES A.P.I.
ABSOLUTE VISCOSITY = 24.2 POISES
1 CENTISTOKE = (STOKE/100) 1 STOKE = 100 CENTISTOKES
1 CENTIPOISE = (POISE/100) 1 POISE = 100 CENTIPOISES
SPECIFIC GRAVITY 60/60°F
VISCOSITY CONVERSION CHART

Figure 2

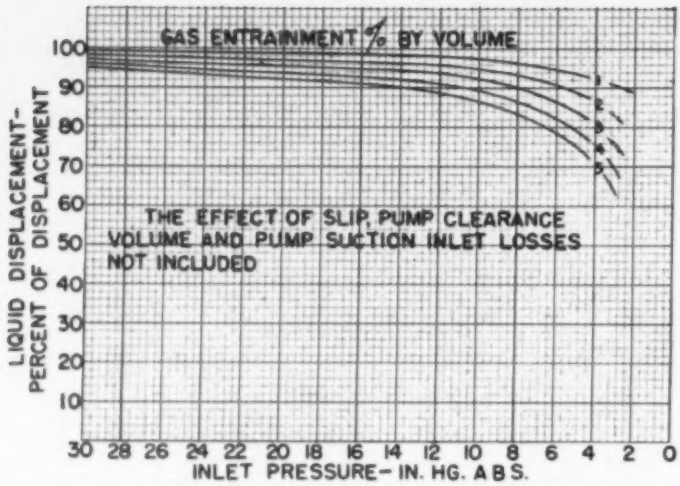

GAS ENTRAINMENT % BY VOLUME
LIQUID DISPLACEMENT-
PERCENT OF DISPLACEMENT
THE EFFECT OF SLIP, PUMP CLEARANCE
VOLUME AND PUMP SUCTION INLET LOSSES
NOT INCLUDED
INLET PRESSURE – IN. HG. ABS.

Figure 3[3]. Effect of Entrained Gas Only on Liquid Displacement of Rotary Pumps. (Reprinted from the Standards of Hydraulic Institute, Rotary Pump Section, Copyright 1947 by Hydraulic Institute, New York.)

it is often difficult to obtain pressure readings since the small lines to the gauge become plugged with the sluggish materials. This difficulty can be overcome by installing a riser of 2 or 3-inch pipe. Cap the top, making sure that it is air tight. Install the gauge on the cap, and for additional safety use a few coils of copper pipe between the cap and the gauge. Fill the coils with kerosine or light lubricating oil. The riser will act as an air dome and pressure readings may be obtained without ruining the gauge.

Figure 2 is a convenient chart for converting viscosity readings to absolute viscosities in poises.

Recently there have become available some useful curves showing the expansion of entrained air or gas, also the effect of dissolved gas in the liquid being handled when the pressure is reduced below atmospheric in the piping or inlet ports of a pump.

Figures 3 and 4 are well worth application in piping designs as they readily show what pump manufacturers have found by experience, namely that if a flooded suction can be provided, many hard jobs become easy.

If the partial pressure in the suction line can be kept within such limits that there is from 7½ to 10 pounds absolute pressure, or, as shown on the curves, from 15 to 20 inches Hg. absolute at the pump inlet, then most of the troubles disappear. In many installations, however, the nature of the process requires the system to operate at a low absolute pressure. When there are pressures from 0 pounds absolute to 7½ pounds absolute, particular attention must be given to size of pump, pump speed, and piping details to obtain the most satisfactory installation. A study of the above curves, Figures 3 and 4, shows the obvious effect of pumping in the low absolute pressure range. Gas expansion in the suction line and pump results in decreased liquid delivery.

Many designers do not realize the prevalence of dissolved and entrained gasses. Practically all liquids will dissolve air. Water at 60° F. will dissolve air to 3 percent of its volume. If carbon dioxide gas is present it will dissolve 6 percent. Lubricating and transformer oils will dissolve up to 10 percent air, and gasoline up to 20 percent under favorable conditions.

Molasses is full of CO_2 bubbles encased in a tough film of molasses. The whole mass will expand under reduced pressure. One laboratory test developed that 1 cubic foot of molasses expanded to 1¼ cubic feet in volume when the pressure was reduced to 7½ pounds absolute.

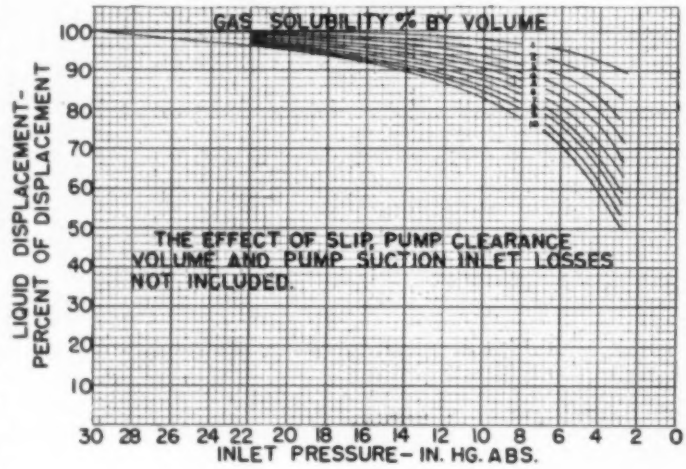
Entrained air is usually caused by leaks in the suction piping, or through the bonnets of valves or other packed fittings. As shown by the following table, it is obvious that the total of several such leaks may seriously affect the pump capacity.

Each cubic foot displaces 7.5 gal-

TABLE 2

Type Fittings[6]	Estimated Average Air Leakage Lb./Hr.	Cu. Ft. per Min. at Atmospheric Pressure and 70° F.
Screwed connections in sizes up to 2"	.1	.021
Screwed connections in sizes up above 2"	.2	.043
Flanged connections up to 6"	.5	.117
Flanged connections 6" – 24" including manholes	.8	.172
Flanged connections 24" – 6'	1.1	.236
Flanged connections above 6'	2.0	.430
Packed valves up to ½" stem dia.	.5	.117
Packed valves above ½" stem dia.	1.0	.214
Lubricated plug valves	.1	.021
Petcocks	.2	.043
Sight glasses	1.0	.214
Gage glasses including gage cocks	2.0	.430
Liquid sealed stuffing box for shaft of agitators, pumps, etc. per in. dia.	.3	.064
Ordinary stuffing box per in. dia.	1.5	.321
Safety valves and vacuum breakers per inch of nominal size	1.0	.214

Figure 4[3]. Effect of Dissolved Gas On Liquid Displacement of Rotary Pumps. (Reprinted from the Standards of Hydraulic Institute, Rotary Pump Section, Copyright 1947, by Hydraulic Institute, New York.)


GAS SOLUBILITY % BY VOLUME
LIQUID DISPLACEMENT-
PERCENT OF DISPLACEMENT
THE EFFECT OF SLIP, PUMP CLEARANCE
VOLUME AND PUMP SUCTION INLET LOSSES
NOT INCLUDED.
INLET PRESSURE – IN. HG. ABS.

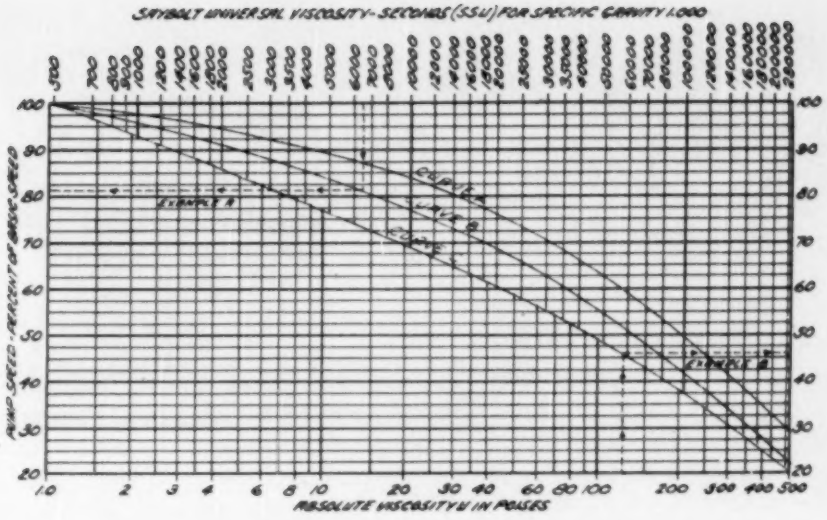

SAYBOLT UNIVERSAL VISCOSITY - SECONDS (SSU) FOR SPECIFIC GRAVITY 1.000
PUMP SPEED - PERCENT OF BASIC SPEED
ABSOLUTE VISCOSITY N IN POISES
EXAMPLE A
EXAMPLE B
CURVE C
CURVE B
CURVE A

Figure 5. Relation of Pump Speed to Viscosity.

Example A. SD 844 with viscosity 6500 SSU. From Curve B "Pump Speed" is 81¼ percent of 400 rpm. basic speed or 325 rpm.
Example B. SD 866 pump with molasses viscosity 125 poises and gravity 1.44, kinematic viscosity 86.7 Stokes = 40,000 SSU.
Then, from Curve C "Pump Speed" is 46 percent of 390 rpm. basic speed or 179 rpm.

Note: The pump manufacturer first determines the suitable basic speed for each size and design of pump when handling free-flowing liquids of 500 SSU or less. For liquids where specific gravity is 1.000 or less, use values of Seconds Saybolt Universal to determine "Pump Speed"—Percent of Basic Speed."

For liquids where gravity is greater than 1.000, use values of Absolute Viscosity in poises to determine "Pump Speed—Percent of Basic Speed."

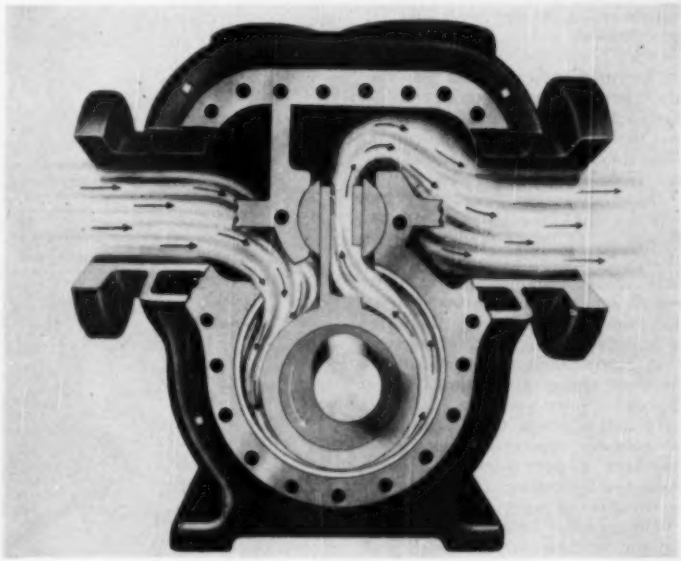
lons of the available liquid capacity and unfortunately Boyle's law works exactly the same in a liquid pump as it does in a vacuum system.

Heavy steam cylinder stock lubricating oil, molasses, and other liquids with a high film strength occasionally contain abnormal quantities of entrained air. Molasses tankers, loaded by lines to the hatches, with a stream dropping 25 to 30 feet through the air, have entrained up to 20 percent air. Storage tanks filled over the top, have entrained similar quantities and it takes months for it to work its way to the top surface. Fortunately rotary pumps will handle air and liquids, but proper allowances should be made for such conditions if they are likely to be present.

For many years another guess was the friction power required within the pump because of the rotation of the parts in viscous, sticky liquids. This problem has had considerable research and now for a pump with known surface areas, clearances and operating speed, the horsepower required for a liquid of known viscosity is obtainable. From such data, the additional power for increased viscosity may be computed. With all types, the power increases rapidly with the increase in the rotating speed, and for at least two types, the power required varies with the square root of the absolute viscosity.

As a result of these studies, it develops that frequently it is worth while to use a large pump operating at low speed rather than a small unit at high speed. Some of the additional cost of the pump is saved in the cost of the prime mover, and the savings

Figure 6. The liquid flows through suction port. Piston immediately begins forcing out liquid.



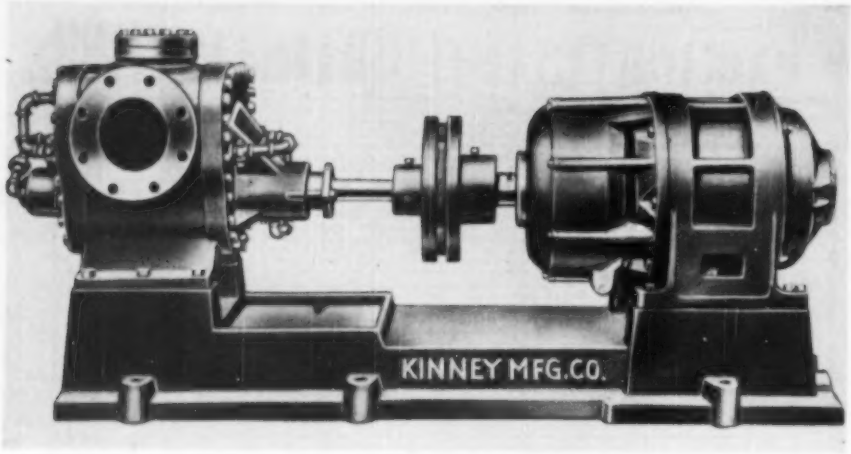


Figure 7. Electric Gear Motor Drive.

in operating cost and longer service without repairs provide additional economies.

Figure 5[7] shows the adaptation of speed to viscosity for several sizes of pumps.

Power savings alone are not the sole reason for the use of such speed modifications. The pump cannot crawl down the pipe to get the liquid. As sea level there is atmospheric pressure of 14.76 psi. or, roughly 1 Kgcm.[8] All the pump can do is to produce a partial pressure in the suction pipe. No more liquid will reach the pump than the differential pressure will force through the pipe. Since some of this must be used to overcome friction, some more to elevate the liquid if the source of supply is below the pump, too frequently there is little left to force the liquid through the pump inlet to the rotors and fill them in the time they are exposed to the suction port. As the size of the suction ports is increased and the pump slowed down, it, at the same time, insures the rotors will fill and improve the pump performance.

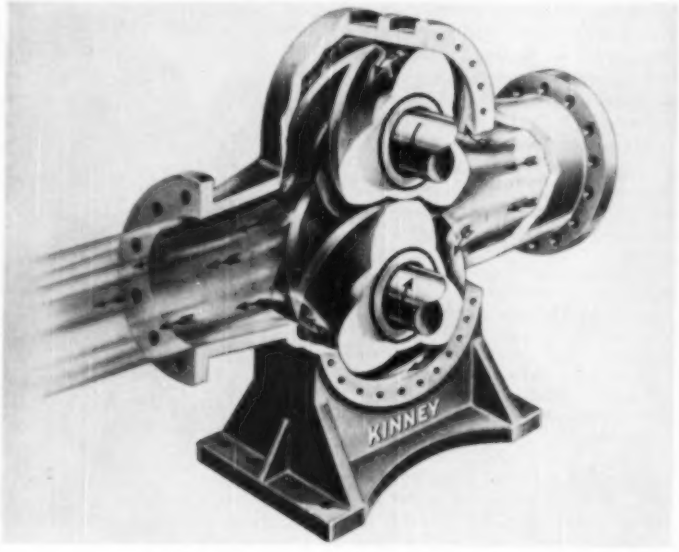
Developments in foundry practice and in metallurgy have helped too. Pumps are no longer necessarily built of iron or bronze. Cast steel, stainless steel, monel and other nickel alloys are all coming into more common use and have added their bit to improved technical application. Tables are available showing the proper metals to use for best service for a long list of liquids.[8]

In keeping with the accumulation of valuable engineering data, there has been a corresponding improvement in the mechanical features and construction of rotary pumps.

Figures 6 and 7 show one of the first rotaries to enter the industrial field. It was the first pump to be jacketed for handling asphalt and materials that are solid or semi-solid when cold, and has been built for capacities up to 3200 gpm. when handling heavy Navy bunker oil. The liquids should have some lubricating value as the parts operating in the material being pumped must be maintained with reasonably close tolerances.[9]

Figures 8 and 9 show a pump of modified gear type which does not require a lubricating material. There is no metallic rubbing of rotor surfaces. Bearings are outside of the pump casing and do not depend on the lubricating value of the liquid passing through the pump. The auxiliary rotor is driven from the main shaft by timing gears which operate in an oil bath. This eliminates the necessity of transmitting power through the rotors and thus permits cutting the rotors on a long angle to prevent trapping at the root of the teeth which, in turn, means a reduction in internal power loss and quieter operation. Independent thrust bearings are an important feature of this pump. They eliminate endwise motion of the rotors and this results in less wear on faces of the heads and rotors and a reduction in power loss.

Figure 8. Rotors Assembled in Cylinder.



This type also can be jacketed.[10]

Figure 10 shows an interesting type pump developed for handling a special problem. Asphalt shingle manufacturers found that mixing from 25 to 40 percent of finely ground glass or silica dust with coating asphalt greatly improved their product. The asphalt has a melting point of 200° F. or more, and the mixture is semi-plastic and highly abrasive.[11]

By placing the timing gears and bearings in a separate case, jacketing the cylinder and stuffing box areas, heat treating the rotors and shaft sleeves to a hardness of 600 Brinnell, and supplying easily removable head liners, a pump was produced which not only gave good performance but permitted of renewal of wearing parts with a minimum of labor and expense. This material, like white lead and chilled grease, requires a gravity or forced feed to fill the rotors.

Wood rosin was considered not pumpable until recently. It is solid when cold, very thin when hot, and then impregnates almost any packing. When the pump is shut down, the packing freezes to the shaft. A jacketed pump, jacketed stuffing boxes to heat the pump before starting, then using cold water to cool the stuffing boxes when in operation, made it practical to ship this material in tank cars. The wooden barrel, and shipping rosin as a solid became obsolete. The savings were enormous.

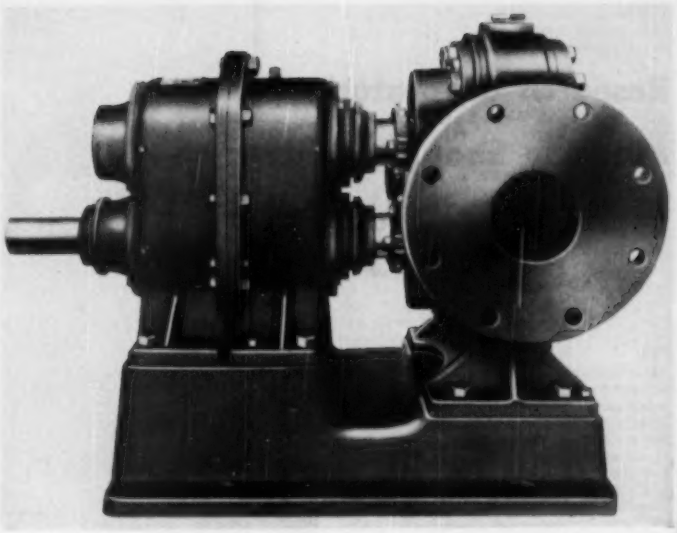
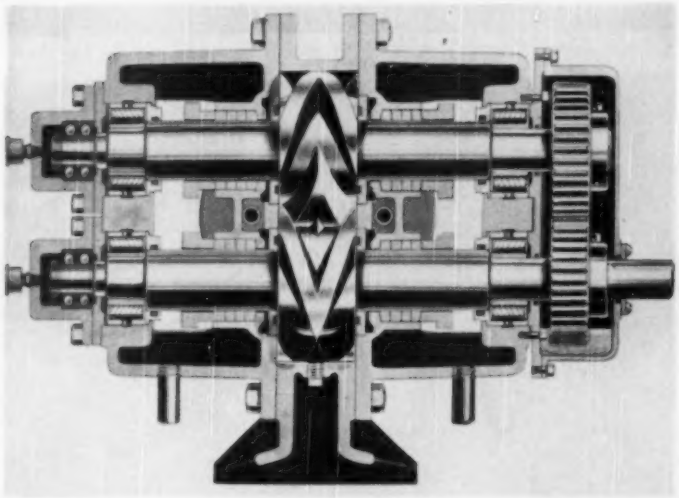


Figure 10. Special Pump Developed for Asphalt Shingle Manufacture.

The application of present knowledge on friction losses, pump speeds, and pumps makes it worthwhile to restudy many existing installations. Frequently, larger suction lines, relocation of pumps, and perhaps the use of variable speed driving units will obviate unnecessary heating of storage tanks, reduce the size of boilers and heat exchangers, cut fuel and power bills, and so greatly improve performance that replacement of present facilities will prove economical.

To summarize: Today almost any material can be pumped if it will squeeze to a film under pressure. Most of the pump troubles do not exist. They are, instead, difficulties encountered before the liquid reaches the pump, and the application of information now available regarding pipe friction losses, effect of gasses, inlet losses, and velocities of moving parts will produce much more satisfactory and economical installations.

Figure 9. Modified Gear Pump with Thrust Bearings.



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[6] Selection and use of Ejectors, by D. H. Jackson, Chemical Engineering Progress, Vol. 44, No. 5, page 357 (1948).

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[9] Bulletin L48—pp. 7, 14 and 15. Kinney Manufacturing Company, Boston 30.

[10] Bulletin L48—pp. 16, 17 and 36. Kinney Manufacturing Company, Boston 30.

[11] Bulletin L48—page 32. Kinney Manufacturing Company, Boston 30.

ACKNOWLEDGMENT

Figures 3 and 4 reprinted from the Standards of Hydraulic Institute, Rotary Pump Section, Copyright 1947 by Hydraulic Institute, 30 West Street, New York 6.

* * *

Research Laboratories Machine Shop Serves Experimental Programs

THE spectacular growth of industrial research during the past few years has made necessary the enlargement of many laboratory metal-working shops. Among those recently expanded is the new machine shop of Gulf Oil Corporation's research laboratories at Harmarville, Pa.

Planned to function 100 percent as a "tool" for the oil firm's research and exploratory work, the shop is supplying all metal-working requirements of the laboratories' staff of chemists, physicists, and engineers.

By the very nature of the work, a great many of the parts specified by Gulf's research staff cannot be obtained in the open market. Requests usually are for "one-of-an-item" parts which can be made under close supervision of the designer and frequently more quickly than were the work to be given to job shops. Rarely are jobs let to outside suppliers.

Products of the Gulf shop probably are greatly diversified ranging from clocks to harvesters used to gather pyrethrum daisies for use in the company's insecticides. Commonplace are such jobs as the grinding of crankshafts and the making of complete units or experimental parts for gyroscopes, high altitude airplane engine pumps, various gauges, rolling ball viscometers, and a chassis dynamometer.

Among notable "firsts" constructed

Primarily for instrument plating, this shop off the main floor of the machine shop was designed by laboratory engineers. Copper, nickel, chrome, silver, gold, cadmium, lead, tin, and indium are used for plating. Blower vent system carries off fumes, and lamps are vapor-proofed for further safety.

Looking down the main floor of Gulf Research machine shop at Harmarville, Pa. Glassed-in rooms are clerical office, inspection shop, grinding room, paint shop, plating shop, and stock room. Most machines are faced the same way to facilitate supervision and enhance orderliness.

Inspection work of the machine shop is conducted in this air- and temperature-controlled room off the main work floor. It is equipped with all modern gage instruments (many of which the shop makes itself), comparator, electrolimit gage, profilometer, jeweler's bench and tools.

here is the Gulf two-cylinder test engine.

Another important role of the shop is that of testing cutting and grinding oils. Products developed by the laboratories' Lubrication division are evaluated here in both normal and special test machining operations.

Equipment and Facilities

The new machine shop has 18,479 square feet of floor space. The main shop and assembly floor occupies 10,676 square feet, while storage space in the basement and mezzanine consumes slightly more than 2500 square feet. Supervisory offices and supplementary rooms occupy the remainder.

A grinding room, where a large part of the laboratories' testing of thread-grinding oils is conducted, is partially sound-proofed and is included in the row of special shops. Next to it is a paint shop with explosive-proof fixtures and a high-suction spray booth. The electro-plating room, of original design, is a model of efficiency.

Welding and sheet metal work is carried out in another sound-proof room, next to the assembly bay. All inspections are made in air-conditioned, temperature-controlled quarters equipped with a comparator, an electro-limit gauge, a super micrometer, and a jeweler's bench and tools. The stock room carries some 2600 different items.

The shop is operated as a responsibility of R. J. S. Pigott, director of the engineering division. It is under the immediate supervision of Superintendent F. F. Versaw. The basic policies responsible for its performance may be summarized as exact time and cost accounting, careful selection and training of research mechanics, best working conditions in every respect, and tooling and organization of the shop to ideally serve its specific function.

Centralization, or the grouping under one roof of all shop and allied services such as welding, painting, etc., is considered a major advantage over having individual and smaller shops assigned to laboratory departments.

The shop floor proper has been arranged into three units of machines and benches. Each unit is similarly equipped and virtually is a complete shop in itself.

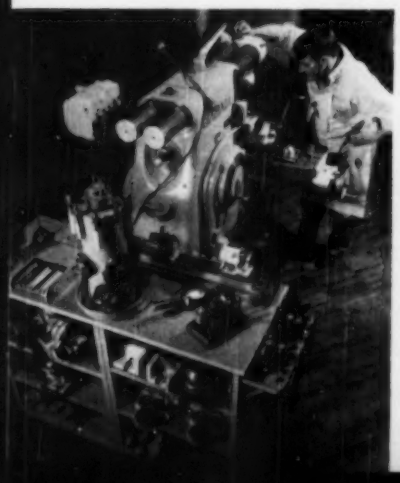
The cost and accounting systems used in the machine shop of the Gulf Research Laboratories are so detailed and complete that each hour of every man and machine can be traced for the past seven years.

Probably more valuable than any other single factor is the ability of the shop to render fast service. Although months may be necessary for the concept of a new research development, it almost invariably comes to the shop as a hurry-up job. Personal supervision and consultation by the scientist who has asked that a job be done eliminates considerable delay.

The experimental field is relatively narrow and men with the desired training and experience are so difficult to find that the laboratory has developed a program of training. Each selected trainee serves a 10,000 hour apprenticeship during which he does all types of work under the supervision and guidance of an expert craftsman. Each worker must have a high degree of initiative and is charged with the responsibility of carrying his assignments through all operations to final completion.

The fact that the present staff of 90 men is engaged primarily on creative projects, to which their own resourcefulness contributes, increases job interest.

At right — A separate grinding room with sound-proofed ceiling contributes to the quietness of the Gulf Research machine shop. Here, besides grinding operations required on shop work, constant testing of Gulf's grinding oils is conducted in cooperation with oil-development technicians.



At left—Tool racks at all milling machines help deliver finished work in minimum time by eliminating trips to the tool room. Racks carry cutters, parallels, chucks, and all milling machine accessories.

THERMOCHEMISTRY for the Petrochemical Industry

Part IX—The Halogens and Halogen Acids

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***THE HALOGENS** and halogen acids form an industrially important group of compounds. Increasing interest in the manufacture of petroleum chemicals indicates a considerable application for the thermodynamic properties of these compounds. Earlier articles[12, 13, 14, 15, 16, 17, 18, 19] have presented the thermodynamic properties of the principal hydrocarbons, of the combustion gases, and of the sulfur compounds. Dr. Kobe is a professor of chemical engineering at the University of Texas and Mr. Long, formerly a Celanese fellow at Austin, is now connected with Johns-Manville.*

CHLORINE and hydrogen chloride are by far the most important of the halogens. This relative importance is clearly reflected by the interest shown in their thermodynamic properties in Table 1. The chemical nature, high reactivity and tendency to polymerize, has made calorimetric determinations very difficult, unreliable or impossible. The molecular structure being relatively simple has made the group suitable for accurate statistical calculations.

Murphy and Vance[25] in 1939 reported spectroscopically determined heat capacities for fluorine and hydrogen fluoride. These are the only data in the literature on the heat capacities of gaseous fluorine and hydrogen fluoride. Low temperature heat capacity measurements on solid and liquid hydrogen fluoride were made by Clusius, Hiller and Vaughen[6] and Dahmlos and Jung.[7] Hydrogen fluoride polymerizes in several forms but the literature data[2, 3, 20] are conflicting as to the form and equilibria. The data of Murphy and Vance[25] were used in this paper for both fluorine and hydrogen fluoride.

Chlorine has been the subject of much work. Table 1 shows a lot of unreliable data which have been included for historical interest only. The most recently published

TABLE 1
Reported Heat Capacity Data for the Halogens and Halogen Acids

Compound	Temperature Range	Method	Workers	Reference
F_2	298 to 2000° K.	Spectroscopic	Murphy and Vance	25
Cl_2	13 to 200°C.	Calorimetric	Regnault	29
	0°C.	Velocity of sound	Streeker	35
	6°C.	Velocity of sound	Martini	21
	16°C.	Velocity of sound	Partington	27
	318 to 452° K.	Calorimetric	Eucken and Hoffmann	6
	273 to 2000° K.	Spectroscopic	Nernst and Wohl	26
	20 to 2300°C.	Spectroscopic	Bruckner	4
	100 to 2000° K.	Spectroscopic	Trauts and Ader	36
	300 to 1500° K.	Spectroscopic	Spencer and Justice	33
	298 to 1500° K.	Spectroscopic	National Bureau of Standards	30
Br_2	83 to 228°C.	Calorimetric	Regnault	29
	298 to 1500° K.	Compilation	National Bureau of Standards	30
	200 to 1600° K.	Spectroscopic	Gordon and Barnes	10
I_2	185°C.	Velocity of sound	Stevens	34
	298 to 1500° K	Spectroscopic	National Bureau of Standards	30
HF	298 to 2000° K.	Spectroscopic	Murphy and Vance	25
HCl	0°C.	Velocity of sound	Mason	22
	15 to 200°C.	Calorimetric	Regnault	29
	20°C.	C_p ratio	Streeker	35
	20°C.	Velocity of sound	Schweikert	32
	1 to 600° K.	Spectroscopic	Hutchisson	11
	273 to 2500° K.	Spectroscopic	Nernst and Wohl	26
	600 to 2000° K.	Spectroscopic	Austin	1
	300 to 2000° K.	Spectroscopic	Bryant	5
	298 to 1500° K.	Compilation	National Bureau of Standards	30
	300 to 1500° K.	Spectroscopic	Spencer and Justice	33
HBr	20°C.	Velocity of sound	Streeker	35
	20°C.	Calorimetric	Muller	24
	600 to 2000° K.	Spectroscopic	Austin	1
	298 to 1500° K.	Compilation	National Bureau of Standards	30
	200 to 1600° K.	Spectroscopic	Gordon and Barnes	10
HI	20°C.	C_p ratio	Streeker	35
	600 to 2000° K	Spectroscopic	Austin	1
	298 to 1500° K.	Compilation and Spectroscopic	National Bureau of Standards	30
	273 to 2000° K.	Spectroscopic	Pennington	28

TABLE 2
Standard Heats of Formation and Free Energies of Formation of the Gaseous Halogens and Halogen Acids[1]

Compound	Molecular Weight	$\Delta H_f°$(25°C.) cal./g-mole	$\Delta G_f°$(25°C.) cal./g-mole
F_2	38.00	0	0
Cl_2	70.914	0	0
Br_2	159.832	7,340[2]	751
I_2	253.84	14,876[3]	4,630
HF	20.01	—64,200	—64,700
HCl	36.465	—22,063	—22,769
HBr	80.924	— 8,660	—12,740
HI	127.93	6,200	4,630

[1] $\Delta H_f°$ and $\Delta G_f°$ represent the changes in the heat content (enthalpy) and free energy, respectively, for the formation of the gaseous compounds from the elements, with all the reactants and products in their appropriate standard reference states.
[2] The standard reference state for bromine is the liquid at 25°C.
[3] The standard reference state for iodine is the solid form at 25°C.

TABLE 3
Heat Capacities of Halogens and Halogen Acids
cal./g-mole · °C.

°C.	F_2	Cl_2	Br_2	I_2	HF	HCl	HBr	HI
0	7.397	7.99	8.553	8.79	6.962	6.961	6.962	6.957
18	7.488	8.08	8.601	8.80	6.962	6.962	6.964	6.959
25	7.522	8.11	8.618	8.81	6.963	6.962	6.964	6.960
100	7.825	8.36	8.745	8.87	6.965	6.968	6.977	6.983
200	8.120	8.58	8.847	8.93	6.967	6.990	7.020	7.066
300	8.323	8.71	8.899	8.97	6.980	7.045	7.110	7.207
400	8.471	8.81	8.940	9.00	7.005	7.139	7.236	7.381
500	8.571	8.88	8.969	9.02	7.050	7.258	7.383	7.558
600	8.644	8.92	8.994	9.04	7.115	7.394	7.536	7.729
700	8.698	8.95	9.015	9.06	7.195	7.532	7.685	7.885
800	8.740	8.98	9.035	9.07	7.283	7.661	7.828	8.027
900	8.770	9.01	9.055	9.08	7.380	7.801	7.962	8.150
1000	8.797	9.03	9.073	9.10	7.482	7.921	8.080	8.259
1100	8.814	9.05	9.091	9.11	7.587	8.030	8.188	8.362
1200	8.830	9.07	9.109	9.13	7.689	8.130	8.284	8.440
1300	8.842				7.787			8.515
1400	8.853				7.881			8.582
1500	8.864				7.970			8.641
1600	8.871				8.052			8.694
1700	8.879				8.131			8.742

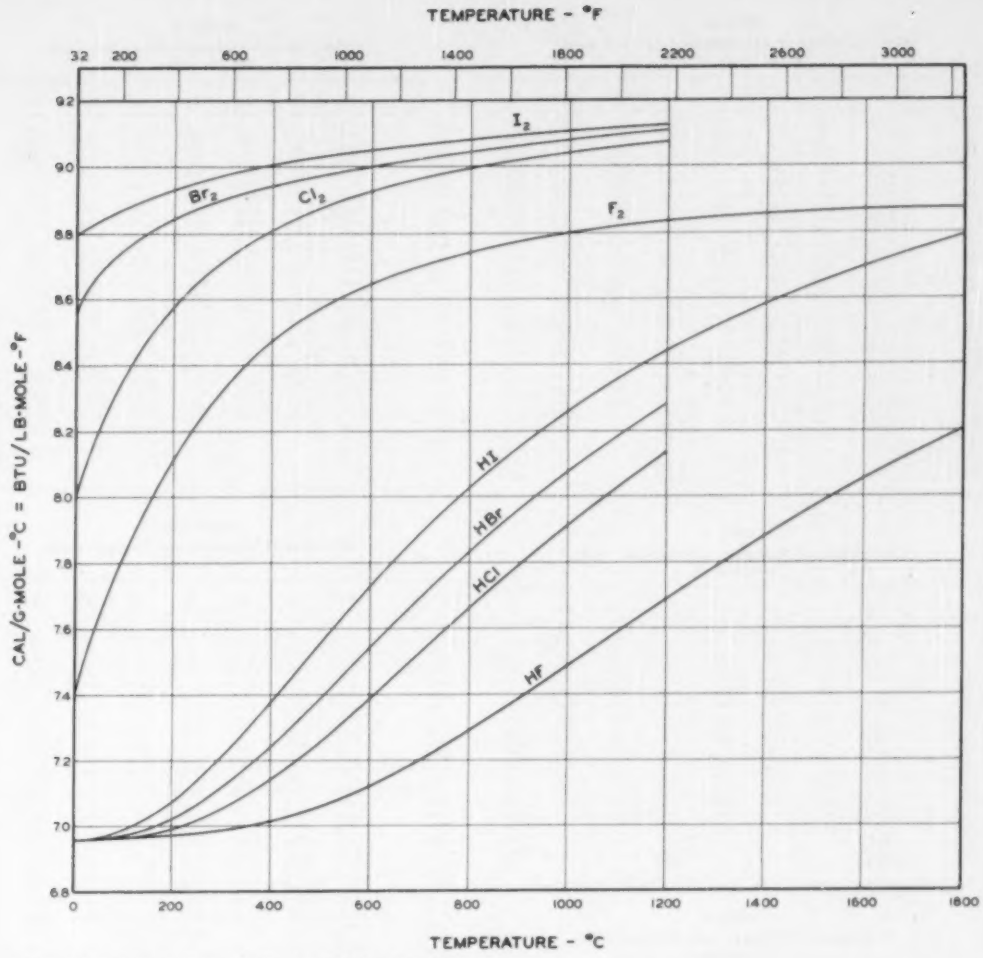

Figure 1. (above) Heat Capacity Curves for Fluorine, Chlorine, Bromine, Iodine, Hydrogen Fluoride, Hydrogen, Chloride, Hydrogen Bromide and Hydrogen Iodide.

TABLE 4

Heat Capacities of Halogens and Halogen Acids
cal./g-mole • °K.

°K.	F_2	Cl_2	Br_2	I_2	HF	HCl	HBr	HI
273	7.397	7.99	8.553	8.79	6.962	6.961	6.962	6.957
291	7.488	8.08	8.601	8.80	6.962	6.962	6.964	6.959
298	7.522	8.11	8.618	8.81	6.963	6.962	6.964	6.960
300	7.530	8.12	8.622	8.82	6.963	6.963	6.964	6.960
400	7.912	8.44	8.777	8.90	6.969	6.970	6.985	6.998
500	8.184	8.62	8.859	8.95	6.970	7.000	7.040	7.099
600	8.373	8.74	8.911	8.98	6.984	7.066	7.141	7.251
700	8.502	8.82	8.948	9.00	7.015	7.167	7.276	7.427
800	8.593	8.88	8.976	9.02	7.066	7.292	7.427	7.605
900	8.661	8.92	9.000	9.04	7.134	7.429	7.580	7.773
1000	8.711	8.96	9.021	9.06	7.217	7.569	7.728	7.925
1100	8.748	8.99	9.041	9.07	7.309	7.705	7.867	8.052
1200	8.777	9.02	9.060	9.09	7.408	7.833	7.996	8.161
1300	8.800	9.04	9.078	9.10	7.510	7.951	8.112	8.257
1400	8.819	9.06	9.095	9.12	7.613	8.058	8.216	8.379
1500	8.835	9.08	9.113	9.13	7.714	8.154	8.309	8.461
1600	8.847		9.132		7.811		8.390	8.533
1700	8.858				7.904			8.598
1800	8.866				7.992			8.655
1900	8.873				8.075			8.707
2000	8.880				8.151			8.754

TABLE 5

Heat Capacities of Halogens and Halogen Acids
Btu./lb.-mole • °F.

°F.	F_2	Cl_2	Br_2	I_2	HF	HCl	HBr	HI
32	7.397	7.99	8.553	8.79	6.962	6.961	6.962	6.957
60	7.476	8.08	8.598	8.80	6.962	6.961	6.963	6.959
77	7.522	8.11	8.618	8.81	6.963	6.962	6.964	6.960
100	7.581	8.16	8.645	8.83	6.963	6.962	6.966	6.962
200	7.807	8.35	8.737	8.87	6.964	6.968	6.974	6.980
300	7.981	8.49	8.799	8.91	6.965	6.978	6.982	7.014
400	8.132	8.59	8.844	8.94	6.969	6.992	7.023	7.072
500	8.257	8.66	8.878	8.96	6.973	7.019	7.070	7.143
600	8.356	8.73	8.906	8.98	6.982	7.060	7.127	7.233
700	8.436	8.78	8.930	8.99	6.996	7.110	7.200	7.328
800	8.502	8.82	8.948	9.00	7.015	7.170	7.275	7.426
900	8.557	8.85	8.965	9.01	7.040	7.233	7.359	7.526
1000	8.601	8.88	8.980	9.02	7.072	7.306	7.442	7.624
1100	8.640	8.91	8.992	9.03	7.110	7.382	7.527	7.718
1200	8.672	8.93	9.004	9.04	7.152	7.460	7.612	7.808
1300	8.700	8.95	9.016	9.05	7.197	7.538	7.695	7.892
1400	8.721	8.97	9.028	9.06	7.246	7.613	7.774	7.973
1500	8.742	8.99	9.039	9.07	7.298	7.690	7.852	8.047
1600	8.761	9.00	9.050	9.08	7.353	7.765	7.927	8.116
1700	8.777	9.02	9.060	9.09	7.408	7.832	7.997	8.182
1800	8.791	9.03	9.070	9.10	7.463	7.900	8.062	8.242
1900	8.801	9.04	9.080	9.10	7.520	7.962	8.125	8.298
2000	8.811	9.05	9.090	9.11	7.578	8.024	8.184	8.350
2100	8.820	9.06	9.100	9.12	7.634	8.080	8.238	8.399
2200	8.830	9.07	9.110	9.13	7.691	8.132	8.290	8.444
2400	8.847				7.800		8.382	8.526
2600	8.858				7.904			8.599
2800	8.867				8.002			8.662
3000	8.874				8.091			8.717

TABLE 6

Heat Capacities of Halogens and Halogen Acids
Btu/lb.-mole · °R.

°R.	F_2	Cl_2	Br_2	I_2	HF	HCl	HBr	HI
492	7.397	7.99	8.553	8.79	6.962	6.961	6.962	6.957
500	7.427	8.02	8.566	8.80	6.962	6.961	6.963	6.958
520	7.476	8.08	8.598	8.80	6.962	6.961	6.963	6.959
537	7.522	8.11	8.618	8.81	6.963	6.962	6.964	6.960
600	7.672	8.24	8.690	8.85	6.963	6.963	6.967	6.967
700	7.873	8.41	8.765	8.89	6.965	6.969	6.980	6.991
800	8.049	8.53	8.820	8.92	6.967	6.982	7.003	7.033
900	8.184	8.62	8.859	8.95	6.970	7.002	7.040	7.100
1000	8.294	8.69	8.889	8.97	6.976	7.030	7.090	7.189
1100	8.389	8.76	8.916	8.98	6.987	7.074	7.155	7.279
1200	8.463	8.80	8.938	8.99	7.003	7.130	7.228	7.366
1300	8.527	8.84	8.955	9.00	7.024	7.193	7.310	7.465
1400	8.578	8.87	8.971	9.02	7.052	7.262	7.395	7.566
1500	8.621	8.89	8.985	9.03	7.087	7.334	7.480	7.662
1600	8.657	8.92	8.997	9.04	7.127	7.412	7.564	7.755
1700	8.688	8.94	9.010	9.05	7.169	7.488	7.646	7.842
1800	8.711	8.96	9.021	9.06	7.217	7.566	7.727	7.926
1900	8.731	8.98	9.033	9.07	7.266	7.643	7.806	8.003
2000	8.751	8.99	9.044	9.07	7.319	7.718	7.882	8.075
2100	8.768	9.01	9.054	9.08	7.374	7.792	7.954	8.143
2200	8.782	9.03	9.064	9.09	7.430	7.862	8.024	8.206
2300	8.796	9.04	9.074	9.10	7.487	7.928	8.088	8.265
2400	8.807	9.05	9.084	9.11	7.544	7.988	8.147	8.319
2500	8.817	9.06	9.094	9.12	7.601	8.046	8.204	8.371
2600	8.826	9.07	9.104	9.13	7.660	8.102	8.259	8.413
2800	8.841	.....	.....	.....	7.769	.....	8.357	8.503
3000	8.852	.....	.....	.....	7.873	.....	.....	8.578
3200	8.863	.....	.....	.....	7.973	.....	.....	8.644
3400	8.872	.....	.....	.....	8.065	.....	.....	8.702
3600	8.880	.....	.....	.....	8.151	.....	.....	8.755

TABLE 7

Enthalpies of Halogens and Halogen Acids
cal./g-mole

°C.	F_2	Cl_2	Br_2	I_2	HF	HCl	HBr	HI
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	134.0	144.6	154.4	158.3	125.3	125.3	125.3	125.2
25	186.5	201.3	214.7	220.0	174.1	174.0	174.1	173.9
100	762.3	820.0	866.1	882.9	690.0	696.8	696.8	696.9
200	1361.	1469.	1746.	1774.	1392.	1390.6	1395.8	1398.5
300	2584.	2533.	2632.	2670.	2086.	2095.	2102.	2111.
400	3224.	3410.	3525.	3568.	2795.	2804.	2820.	2841.
500	4027.	4293.	4421.	4466.	3491.	3532.	3551.	3589.
600	4938.	5182.	5318.	5367.	4200.	4247.	4296.	4354.
700	5804.	6075.	6218.	6273.	4912.	4997.	5058.	5135.
800	6678.	6972.	7121.	7179.	5643.	5739.	5834.	5931.
900	7554.	7872.	8026.	8091.	6374.	6543.	6625.	6749.
1000	8432.	8774.	8932.	8999.	7120.	7321.	7427.	7561.
1100	9314.	9679.	9840.	9911.	7871.	8118.	8240.	8393.
1200	10195.	10586.	10750.	10829.	8635.	8929.	9064.	9232.
1300	11077.	.....	.....	.....	9410.	.....	.....	10079.
1400	11964.	.....	.....	.....	10290.	.....	.....	10934.
1500	12849.	.....	.....	.....	10990.	.....	.....	11799.
1600	13734.	.....	.....	.....	11780.	.....	.....	12663.
1700	14620.	.....	.....	.....	12590.	.....	.....	13533.

TABLE 8

Enthalpies of Halogens and Halogen Acids
cal./g-mole

°K.	F_2	Cl_2	Br_2	I_2	HF	HCl	HBr	HI
273	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
291	134.0	144.6	154.4	158.3	125.3	125.3	125.3	125.2
298	186.5	201.3	214.7	220.0	174.1	174.0	174.1	173.9
300	200.4	214.9	229.1	237.6	187.3	187.9	188.0	196.9
400	873.4	1044.	1100.0	1123.	884.	883.2	882.9	884.2
500	1779.6	1898.	1982.	2013.	1581.	1581.7	1583.9	1590.4
600	2607.8	2766.	2870.	2909.	2279.	2283.	292.7	2305.2
700	3452.	3645.	3763.	3809.	2979.	2993.	3013.	3041.
800	4307.	4530.	4659.	4709.	3683.	3712.	3748.	3792.
900	5170.	5420.	5559.	5611.	4393.	4446.	4499.	4562.
1000	6039.	6314.	6460.	6516.	5110.	5205.	5265.	5348.
1100	6913.	7211.	7362.	7422.	5836.	5969.	6045.	6147.
1200	7788.	8112.	8267.	8330.	6572.	6746.	6837.	6959.
1300	8669.	9015.	9174.	9239.	7318.	7535.	7642.	7784.
1400	9548.	9761.	10084.	10149.	8074.	8336.	8460.	8617.
1500	10430.	10827.	10994.	11062.	8840.	9147.	9286.	9458.
1600	11314.	.....	.....	.....	9617.	.....	10121.	10284.
1700	12200.	.....	.....	.....	10400.	.....	.....	11165.
1800	13086.	.....	.....	.....	11200.	.....	.....	12028.
1900	13973.	.....	.....	.....	12000.	.....	.....	12896.
2000	14861.	.....	.....	.....	12810.	.....	.....	13799.

spectroscopic calculations are those of Trautz and Ader[36] and Spencer and Justice.[35] These, however, differ as much as a tenth of a calorie at high temperatures. On June 30, 1948, the chlorine heat capacity data were added to the National Bureau of Standards' *Selected Values of Chemical Thermodynamic Properties*.[30] These were calculated[31] using the molecular constants of Spencer and Justice, with partition functions computed from these constants by the

TABLE 9

Enthalpies of Halogens and Halogen Acids
Btu./lb.-mole

°F.	F_2	Cl_2	Br_2	I_2	HF	HCl	HBr	HI
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99	208.2	224.7	240.1	246.3	194.9	194.9	195.0	194.8
77	335.7	362.3	386.5	396.0	313.3	313.3	313.4	312.9
100	509.4	549.6	585.0	598.9	473.4	473.3	473.6	473.2
200	1278.5	1375.	1454.1	1483.9	1169.8	1169.8	1170.6	1170.2
300	2067.1	2218.	2330.9	2373.	1866.2	1867.2	1868.4	1869.8
400	2872.6	3072.	3213.0	3265.	2562.9	2565.	2568.7	2573.9
500	3692.5	3934.	4098.	4160.	3262.	3265.	3273.4	3283.3
600	4523.	4804.	4987.	5057.	3957.	3969.	3983.	4002.
700	5363.	5680.	5879.	5955.	4660.	4677.	4700.	4731.
800	6211.	6560.	6773.	6854.	5366.	5388.	5424.	5469.
900	7066.	7444.	7669.	7754.	6082.	6102.	6155.	6218.
1000	7924.	8331.	8566.	8656.	6765.	6826.	6895.	6976.
1100	8788.	9221.	9464.	9558.	7470.	7558.	7643.	7744.
1200	9651.	10113.	10364.	10461.	8183.	8303.	8401.	8321.
1300	10519.	11007.	11265.	11366.	8911.	9054.	9166.	9306.
1400	11387.	11903.	12167.	12271.	9630.	9813.	9940.	10100.
1500	12260.	12800.	13071.	13178.	10350.	10581.	10721.	10901.
1600	13140.	13700.	13975.	14085.	11090.	11354.	11510.	11710.
1700	14145.	14600.	14881.	14994.	11820.	12139.	12306.	12525.
1800	14898.	15500.	15787.	15903.	12560.	12921.	13109.	13346.
1900	15775.	16410.	16695.	16813.	13320.	13713.	13919.	14174.
2000	16655.	17310.	17603.	17723.	14070.	14510.	14734.	15004.
2100	17534.	18230.	18513.	18634.	14840.	15318.	15555.	15844.
2200	18417.	19130.	19423.	19546.	15600.	16128.	16381.	16685.
2400	20180.	.....	.....	.....	17140.	.....	18049.	18380.
2600	21960.	.....	.....	.....	18720.	.....	.....	20094.
2800	23730.	.....	.....	.....	20310.	.....	.....	21822.
3000	25000.	.....	.....	.....	21910.	.....	.....	23555.

TABLE 10

Enthalpies of Halogens and Halogen Acids
Btu./lb.-mole

°R.	F_2	Cl_2	Br_2	I_2	HF	HCl	HBr	HI
492	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00
500	61.55	64.0	68.48	72.36	55.69	55.69	55.70	55.65
520	208.24	224.7	240.1	246.3	194.9	194.9	195.0	194.8
537	335.7	362.3	386.5	396.0	313.3	313.3	313.4	312.9
600	816.7	877.6	931.7	952.3	750.0	751.9	752.2	751.6
700	1593.8	1710.6	1804.5	1839.	1446.4	1448.7	1449.6	145°.3
800	2389.7	2558.	2684.	2730.	2143.3	2146.4	2148.8	2152.9
900	3203.1	3416.	3568.	3623.	2840.6	28453.	2851.0	2859.0
1000	4022.	4281.	4455.	4519.	3542.	3547.	3558.	3573.
1100	4860.	5154.	5345.	5416.	4240.	4252.	4270.	4295.
1200	5703.	6032.	6248.	6315.	4940.	4962.	4989.	5024.
1300	6554.	6914.	7133.	7214.	5640.	5677.	5716.	5770.
1400	7410.	7799.	8029.	8113.	6345.	6397.	6451.	6524.
1500	8271.	8687.	8927.	9017.	7051.	7117.	7195.	7285.
1600	9132.	9577.	9826.	9919.	7762.	7854.	7947.	8056.
1700	10001.	10470.	10726.	10823.	8476.	8601.	8708.	8839.
1800	10869.	11365.	11628.	11728.	9196.	9360.	9477.	9626.
1900	11739.	12260.	12530.	12634.	9920.	10121.	10253.	10424.
2000	12614.	13160.	13434.	13541.	10650.	10889.	11038.	11227.
2100	13495.	14060.	14339.	14448.	11380.	11666.	11830.	12038.
2200	14372.	14960.	15245.	15358.	12120.	12448.	12628.	12855.
2300	15249.	15870.	16152.	16267.	12870.	13236.	13434.	13678.
2400	16127.	16770.	17060.	17177.	13620.	14031.	14246.	14508.
2500	17010.	17680.	17969.	18087.	14380.	14835.	15063.	15341.
2600	17891.	18580.	18879.	18999.	15140.	15691.	15886.	16172.
2800	19660.	.....	.....	.....	16680.	.....	17548.	17873.
3000	21420.	.....	.....	.....	18250.	.....	.....	19582.
3200	23200.	.....	.....	.....	19830.	.....	.....	21305.
3400	24980.	.....	.....	.....	21440.	.....	.....	23022.
3600	26750.	.....	.....	.....	23060.	.....	.....	24787.

TABLE 11

Mean Heat Capacities of Halogens and Halogen Acids
cal./g-mole · °C.

°C.	F_2	Cl_2	Br_2	I_2	HF	HCl	HBr	HI
0	7.397	7.99	8.553	8.79	6.962	6.961	6.962	6.957
18	7.443	8.04	8.577	8.80	6.962	6.961	6.962	6.958
25	7.460	8.05	8.589	8.80	6.962	6.961	6.962	6.959
100	7.623	8.20	8.661	8.83	6.963	6.964	6.964	6.964
200	7.805	8.34	8.730	8.87	6.965	6.970	6.979	6.993
300	7.947	8.45	8.773	8.90	6.968	6.984	7.007	7.033
400	8.060	8.53	8.813	8.92	6.974	7.010	7.050	7.102
500	8.153	8.59	8.842	8.93	6.983	7.044	7.102	7.178
600	8.230	8.64	8.863	8.95	7.000	7.079	7.160	7.256
700	8.292	8.68	8.883	8.96	7.022	7.116	7.226	7.336
800	8.348	8.72	8.901	8.98	7.049	7.199	7.293	7.414
900	8.393	8.75	8.918	8.99	7.080	7.270	7.361	7.489
1000	8.432	8.77	8.932	9.00	7.116	7.321	7.427	7.561
1100	8.467	8.80	8.945	9.01	7.154	7.380	7.491	7.630
1200	8.496	8.82	8.958	9.02	7.194	7.440	7.553	7.693
1300	8.521	.....	.....	.....	7.235	.....	.....	7.753
1400	8.546	.....	.....	.....	7.278	.....	.....	7.810
1500	8.566	.....	.....	.....	7.322	.....	.....	7.865
1600	8.584	.....	.....	.....	7.366	.....	.....	7.914
1700	8.600	.....	.....	.....	7.407	.....	.....	7.962

relations of Mayer and Mayer.[23] The Bureau of Standards' data were selected as the recommended data.

The calorimetric values of Regnault[29] in 1862 and the

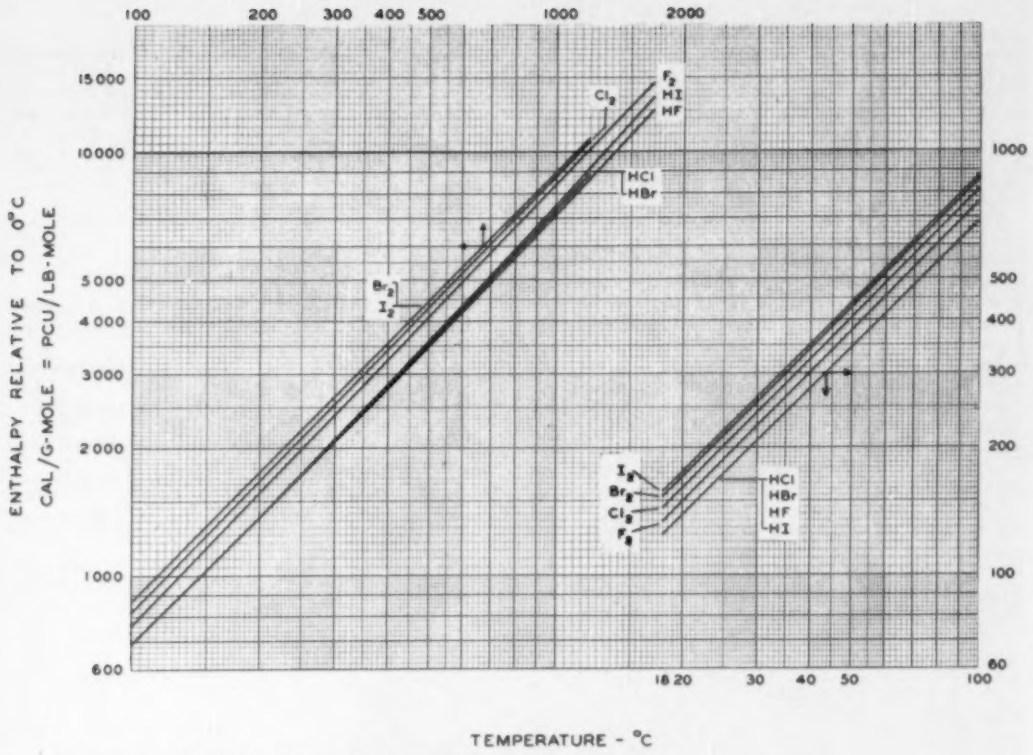

Figure 2. (above) Relative Enthalpies of F_2, Cl_2, Br_2, I_2, HF, HCl, HBr and HI. Multiply readings in Pcu./lb.-mole by 1.8 to obtain Btu./lb.-mole.

TABLE 12

Mean Heat Capacities of Halogens and Halogen Acids
Btu./lb.-mole • °F.

°F.	F_2	Cl_2	Br_2	I_2	HF	HCl	HBr	HI
32	7.397	7.99	8.553	8.79	6.962	6.961	6.962	6.957
60	7.437	8.04	8.575	8.80	6.962	6.961	6.962	6.958
77	7.460	8.05	8.589	8.80	6.962	6.961	6.962	6.959
100	7.491	8.08	8.603	8.81	6.963	6.962	6.963	6.959
200	7.610	8.19	8.655	8.83	6.963	6.963	6.968	6.965
300	7.713	8.28	8.697	8.85	6.964	6.967	6.972	6.975
400	7.806	8.35	8.731	8.87	6.964	6.971	6.980	6.994
500	7.890	8.41	8.756	8.89	6.965	6.978	6.994	7.016
600	7.963	8.46	8.780	8.90	6.968	6.988	7.012	7.046
700	8.029	8.50	8.801	8.91	6.970	7.001	7.036	7.082
800	8.087	8.54	8.819	8.92	6.976	7.013	7.063	7.122
900	8.140	8.58	8.835	8.93	6.981	7.030	7.091	7.164
1000	8.186	8.60	8.849	8.94	6.990	7.052	7.123	7.207
1100	8.229	8.63	8.861	8.95	7.000	7.077	7.156	7.251
1200	8.263	8.66	8.873	8.96	7.012	7.106	7.193	7.295
1300	8.296	8.68	8.884	8.96	7.025	7.140	7.229	7.339
1400	8.324	8.70	8.894	8.97	7.040	7.173	7.266	7.383
1500	8.352	8.72	8.904	8.98	7.056	7.208	7.303	7.426
1600	8.380	8.74	8.913	8.98	7.072	7.241	7.341	7.468
1700	8.405	8.75	8.921	8.99	7.090	7.276	7.378	7.509
1800	8.427	8.77	8.929	8.99	7.109	7.308	7.415	7.549
1900	8.445	8.78	8.937	9.00	7.130	7.341	7.451	7.588
2000	8.463	8.80	8.945	9.01	7.151	7.373	7.487	7.624
2100	8.480	8.81	8.952	9.01	7.173	7.407	7.522	7.661
2200	8.495	8.82	8.959	9.02	7.197	7.439	7.556	7.696
2400	8.524	....	....	....	7.243	....	7.622	7.762
2600	8.551	....	....	....	7.290	....	....	7.825
2800	8.572	....	....	....	7.338	....	....	7.884
3000	8.592	....	....	....	7.385	....	....	7.936

spectroscopic results of Gordon and Barnes[10] constitute the literature on gaseous bromine heat capacity. The National Bureau of Standards[30] report data which differs from that of Gordon and Barnes 0.03 calorie at 1500° K.

TABLE 13

Heat Capacity Equations for Halogens and Halogen Acids
$C_p^\circ = a + b(t) + c(t^2) + d(t^3)$
cal./g-mole • °C. or °K.
Btu./lb.-mole • °F. or °R.

		a	b·10³	c·10⁶	d·10¹⁰	Error Max. %	Error Avge. %	Temp. Range
F_2	°C.	7.424	+3.796	−3.383	+ 9.797	0.78	0.45	273—2000°K.
	°K.	6.115	+5.894	−4.186	+ 9.797			
	°F.	7.356	+2.176	−1.060	+ 1.680			
	°R.	6.115	+3.258	−1.292	+ 1.680			
Cl_2	°C.	8.031	+3.267	−3.840	+15.47	0.50	0.23	0—1200°C.
	°K.	6.8214	+5.7095	−5.107	+15.47			
	°F.	7.973	+1.8901	−1.2101	+ 2.6526			
	°R.	6.8214	+3.1719	−1.5762	+ 2.6526			
Br_2	°C.	8.578	+1.444	−1.603	+ 6.405	0.43	0.15	0—1200°C.
	°K.	8.051	+2.462	−2.128	+ 6.405			
	°F.	8.552	+0.8334	−0.5653	+ 1.098			
	°R.	8.051	+1.358	−0.6568	+ 1.098			
I_2	°C.	8.790	+0.8000	−0.8125	+ 3.125	0.11	0.05	0—1500°C.
	°K.	8.504	+1.3135	−1.0684	+ 3.125			
	°F.	8.775	+0.4604	−0.2558	+ 0.5384			
	°R.	8.504	+0.07297	−0.3298	+ 0.5384			
HF	°C.	6.989	−0.4010	+1.269	− 3.760	0.37	0.09	273—2000°K.
	°K.	7.201	−1.178	+1.576	− 3.760			
	°F.	6.998	−0.2480	+0.2980	− 0.6440			
	°R.	7.201	−0.6550	+0.4870	− 0.6440			
HCl	°C	6.962	−0.3205	+2.322	−10.36	0.22	0.08	0—1200°C.
	°K.	7.244	−1.020	+3.170	−10.36			
	°F.	6.960	−0.2236	+0.7333	− 1.776			
	°R.	7.244	−1.011	+0.9784	− 1.776			
HBr	°C.	6.954	−0.0542	+2.363	−11.61	0.27	0.12	0—1200°C.
	°K.	7.169	−1.604	+3.314	−11.61			
	°F	6.956	−0.0763	+0.7482	− 1.991			
	°R.	7.169	−0.9911	+1.023	− 1.991			
HI	°C.	6.907	+1.011	+0.8230	− 4.813	0.92	0.39	0—1600°C
	°K.	6.702	+0.4546	+1.216	− 4.812			
	°F.	6.890	+0.5449	+0.2900	− 0.8353			
	°R.	6.702	+0.2526	+0.3753	− 0.8353			

and less at lower temperatures. Because the difference is so small and because no details of the Bureau's work are available, the data of Gordon and Barnes were used.

The data of Spencer and Justice[33] for hydrogen chloride, Gordon and Barnes[10] for hydrogen bromide, and Pennington[28] for hydrogen iodide were used in preference to that of the National Bureau of Standards for the same reasons as given above for bromine. The difference never exceeds 0.01 calorie for any of the three.

The standard free energies and heats of formation are given in Table 2, the data coming from the "Tables of Selected Values of Chemical Thermodynamic Properties."

Tables 3, 4, 5 and 6 are compilations of the ideal gaseous molal heat capacities on all four of the temperature scales. These are reproduced graphically in Figure 1.

The enthalpies, relative to 0° C. = 32° F., were obtained by careful integration of the heat capacity-temperature relations of Tables 3-6. From these molal enthalpies, mean heat capacities were calculated. The enthalpy values are reported in Tables 7, 8, 9 and 10 and are graphed in Figure 2 as a double-logarithmic plot. The mean heat capacities are given in Tables 11 and 12.

Empirical heat capacity equations have been derived for each of the eight compounds. As in the previous papers[12,13,14,15,16,17,18,19] these are of the cubic form. The constants for each of the temperature scales are given in Table 13. The maximum error is seen to always be less than one percent.

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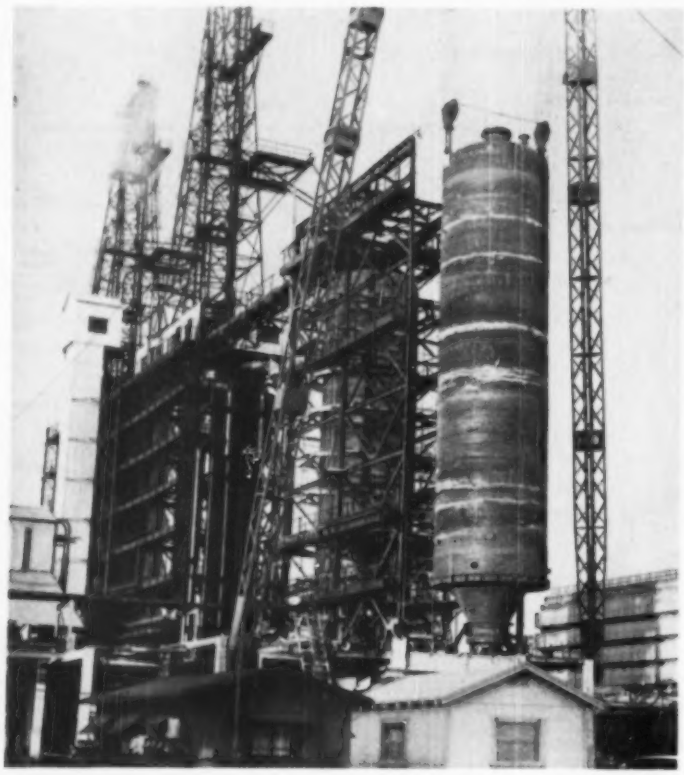

EXPANDED COKER UNIT—Giant cranes lift one of the 120-ton steel drums for General Petroleum Corporation's expanded "coker" at its Torrance, Calif., plant. Surplus heavy fuel oil is cooked in the drums—now numbering six upon the completion of a $2,250,000 expansion project—until it turns to solid coke. The process also produces gasoline, gas oil, dry gas, and petroleum gases. Each drum is 80-feet high and 17-feet in diameter and holds 120,000 gallons of heavy fuel oil in each batch.

The newly expanded unit, a project commenced last July, went on stream late in January. The original unit was taken off stream for maintenance work and to be tied into the new addition.

Working together, the original unit of four coke drums and the two drums just added, will handle about 22,000 barrels of heavy fuel oil each day, producing in excess of 800 tons of coke.

The expansion project was designed by The M. W. Kellogg Company. Construction was handled by the Bechtel Corporation.

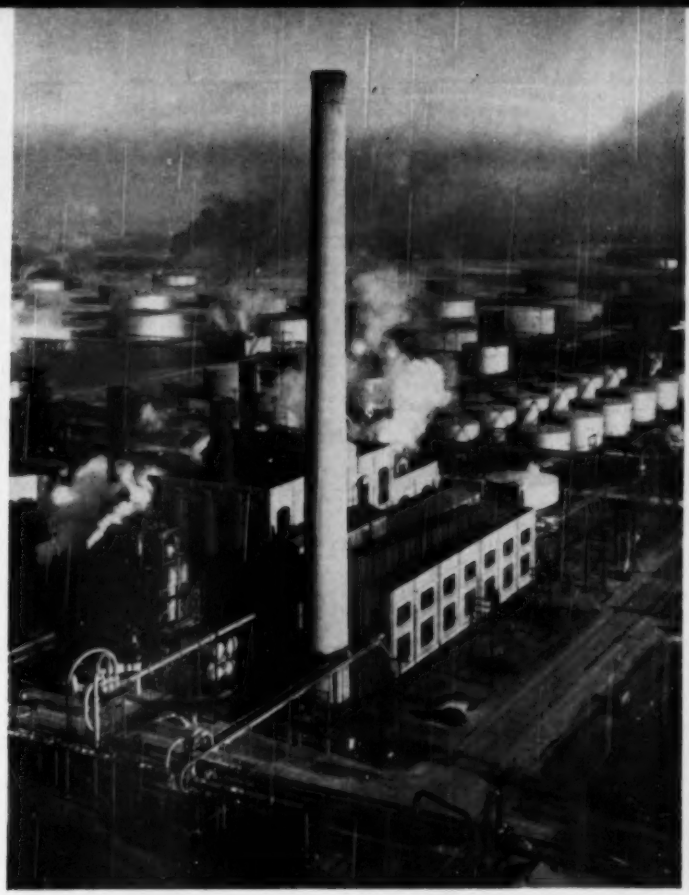

Figure 1. General view of a large completely enclosed refinery boiler plant. Structural costs for plants of this type can be reduced by use of outdoor equipment. Photo courtesy of Standard Oil Company (New Jersey).

Refinery-Utility Cooperative Plants Develop Outstanding Design Features

Power Plants For Modern Refineries

PART II

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THREE excellent examples of refinery-public utility cooperation are now in operation in California, the last plant of which went on the line in 1943. Power plants, one for each of three refineries, were built in accordance with refinery and local load demands. Each refinery has a maximum electrical demand of about 7000 kw. and a maximum process steam load of about 300,000 pounds per hour. Two of the plants, Figure 2A, each is equipped with three 1525-psi., 950° F., 200,000 pounds per hour boilers. The third plant is equipped with six boilers. Pulverized petroleum coke, natural gas, oil, acid sludge, and pitch are the refinery wastes used either singly or in multiple for fuel. Boilers, fans, and water treating equipment are installed outdoors and are of earthquake-resistant construction. Turbines, electrical switchgear, and controls are in a standard type power plant building.

Two 20,000-kw. turbines connected

***BESIDES THE** power plants discussed in Part I, refiners have made use of one other important type. By co-operating with public utilities, several plants serving refineries and the utilities' customers have been constructed. The usual plant of this type supplies steam and electricity to the refinery, a portion of the payment for these services being refinery waste which is used by the utility for steam and power generation. Electrical energy not required by the refinery is sold to utility customers. Several of these plants incorporate outstanding design features which have formed the basis for later designs of many large central station and industrial power plants. This development is covered in Part II. Waste heat boilers and generation of steam from process operations will be discussed in Part III, to appear in an early issue.*

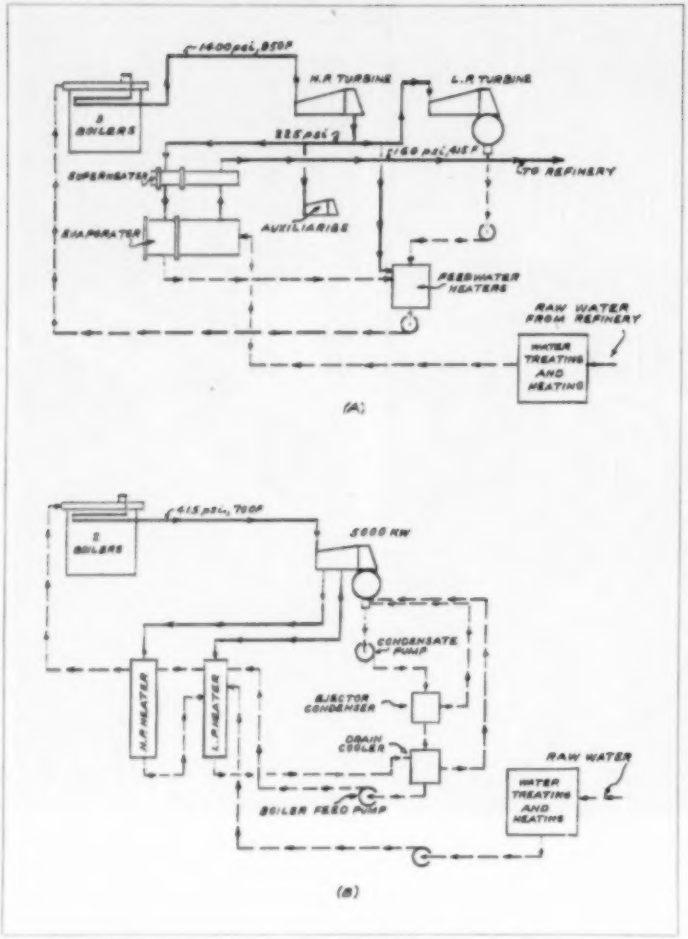


Figure 2. Flow diagrams of typical utility plants serving refiners. (A) One of three similar plants in which refinery process steam is generated in evaporators. Raw water for process steam is furnished by refinery. (B) Smaller capacity station furnishing only electrical power to refiners.

to the same shaft normally produce 40,000 kw. at 12,000 volts, 3 phase. Maximum capacity of the two units is a little over 50,000 kw. High-pressure turbine is non-condensing and exhausts to the low pressure unit at 225 psi. The low-pressure turbine exhausts to a standard steam condenser, condensate being returned to the boilers. A combination automatic extraction and speed governing arrangement permits individual control of high and low-pressure turbines. Steam flow to the high pressure unit is controlled by its exhaust pressure. During periods of light loads the low pressure units' governor permits only cooling steam to flow through the high pressure turbine.

Steam for refinery process use is generated in three or more evaporators by a portion of the 225-psi. exhaust from the high-pressure turbine. Each evaporator has 7500 square feet of heating surface and can produce 102,000 pounds per hour of 170 psi. steam. The refineries supply the water from which the process steam is made. Steam supplied the refineries is at 160 psi. and about 415° F. Condensate is not returned from the refineries, raw water being used instead. This raw feed is first softened and then flows through several heaters and vent condensers before being fed to the evaporators. Steam from the evaporators is superheated in a special heat exchanger by the 225 psi. high pressure turbine exhaust.

The flow diagram of a newer and smaller power plant constructed in conjunction with Southwestern refineries is shown in Figure 2B. Only electric power is supplied to refiner customers, natural gas being used as part payment. Two 35,000 pounds per hour boilers supply 415 psi., 700° F. steam to a 5000-kw. turbine. This is a standard condensing unit; all condensate is returned to the boilers. Extraction at two stages provides steam for feedwater heating. Base load is provided by nearby petroleum customers, the remainder being provided by utility customers.

Perhaps the most famous combined plant is one located at Baton Rouge, La. Completed in 1930, the plant operates at 600 psi. and 750° F. Back in 1930 the 750° F. steam temperature was the highest applicable in the U. S. Using Mississippi River water which contains a high proportion of mud and silt, this plant has a chemical treating system which originally cost almost $1 million. Refinery steam consumption is more than 1.5 million pounds per hour and to generate this steam about 5 million gallons of water must be chemically treated every day. About 18 tons of mud and silt are removed daily from makeup water. Almost every known type of refinery waste can be burned under the eight boilers in the plant. Acid sludge, alkaline sludge, acid tar, pitch bottoms, refinery gas, natural gas, wax tailings, fuel oil, and petroleum coke have all been successfully burned. Many of the fuel and water problems solved during the design and initial operation of this plant formed the basis of central station and industrial practice in later years. Still operating, the plant has led the way in economical production of refinery power and steam.

Advantages of combined refinery-utility power plants make these installations attractive to both firms involved. The refiner is guaranteed a supply of steam at the proper pressure and temperature, obtains electric power generated at low cost utility rates, uses wastes to pay for some of the services received, and makes a smaller initial investment. Operating costs are a minimum because high-pressure, efficient steam plants can be used without the need of refinery-employed central station type personnel. Constant base load, cheap fuel supply, and an expanding connected load make the combined plant attractive to utility owners. Refinery-utility cooperatives have, to date, paid off and it is reasonable to assume that they will continue to do so for refineries where process steam is in greater demand than electric power. For extensive refining operations requiring large quantities of elec-

tric power and steam, the high pressure power plant owned and operated by the refinery is often more economical than the combined type.

Petrochemical Plants

Petrochemical plants use large quantities of 1) electric power, 2) process steam, and 3) process water. Power facilities for these plants are therefore extensive and often include unusual design features. In general, refinery practice which specializes in by-product generation of power is followed in petrochemical power plant design with modifications to suit local conditions.

The flow diagram of a large Houston, Texas, petrochemical power plant is shown in Figure 3. Five 300,000-pounds-per-hour boilers supply 730 psi., 740° F. steam to a 35,000-kw. turbine. Normal fuel used is a mixture of natural gas and waste process gas. Forced and induced draft fans, feed pumps, and other auxiliaries are steam turbine driven because severe electrical storm damage is common in plant vicinity. In emergencies fuel oil can be used as the principal boiler fuel. Feedwater flow is automatically controlled but because process steam demand is almost constant, automatic control of flow is unnecessary. To supplement main turbine exhaust, three waste heat boilers generate 171,000 pounds per hour of 155 psi., 450° F. steam. Main turbine has a maximum capacity of about 41,000 kw. at 13,200 volts. Excess electrical energy is transformed to 66,000 volts and delivered to the local utility's transmission lines. The utility, in turn, furnishes a guaranteed standby capacity of 7000 kva., which eliminates the necessity of a reserve unit in the power plant. All main circuit breakers in the plant are of the air blast type.

At maximum capacity of 41,000 kw. the main turbine exhausts 1,200,000 pounds of steam per hour to the 155-psi., 450°-F. process header. Process steam at 400 psi., 500° F. is obtained by pressure-temperature reduction from the high pressure main. Exhaust from auxiliary turbines furnishes 15-psi. process steam as do medium pressure production units. During periods of small electrical loads, when turbine exhaust quantities are insufficient for process, 155-psi., 450°-F. steam is obtained from two pressure-temperature reducing stations, each with a capacity of 700,000 pounds per hour. About 50 percent of the process steam returns to the power plant as condensate, a condition seldom encountered in refinery power generation. A portion of this condensate is used for desuperheating high pressure steam. To prevent loss

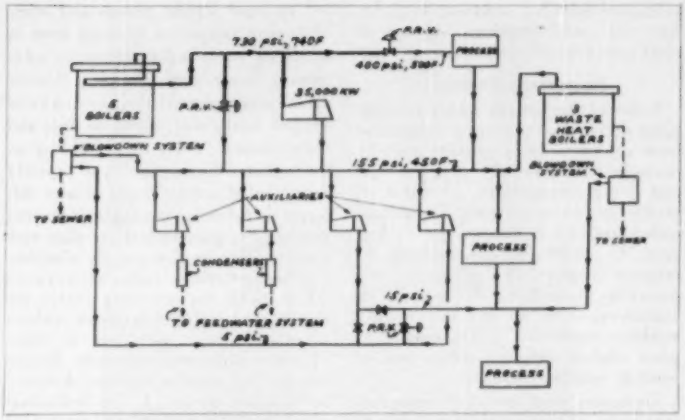


Figure 3. Simplified flow diagram of modern butadiene plant. Five standard steam boilers are supplemented by three waste heat units. Large electrical, steam, and process water demands require extensive power generation facilities.

of desuperheating control, 700,000 gallons of condensate can be stored near the plant. In addition to condensate storage facilities, 22 million gallons of raw process water can be stored in the plant.

Besides the power generating equipment described, extensive water treating, cooling, and storage facilities are provided. Representing a large investment in power and process equipment this plant gives a good indication of trends in petrochemical power plant design. Higher steam pressures and temperatures, larger capacity boilers and turbines, and bigger process preparation facilities all confined within plant limits are some of the problems which today's designers must solve. Solutions presented thus far, when compared with other large industries, have certainly been excellent.

Power Plant Structures

Though some refinery and petrochemical designers lagged behind central station and industrial designers during the '20s and '30s in matters of thermodynamic balance, they led the way in structural and plant housing studies. Semi-outdoor and outdoor plants were developed in the early days of refinery power generating stations. Substantial savings in structural, operating, and maintenance costs were made without reducing equipment life or plant flexibility. Today, refinery installations of this type have capacities well over 40,000 kw. Much that has been learned about outdoor plants by southern, southwestern, and western refiners is of value to designers of plants in other regions where some hesitation has been shown concerning outdoor applications.

Winter temperatures as low as —30° F., high velocity winds, heavy snows, intense rainstorms, and high summer temperatures do not damage well-designed outdoor plants. In some early refinery installations, freezing of draft and feedwater control lines caused trouble, but this danger was readily eliminated by use of insulation or steam trace lines. Other refiners encountered troubles with outdoor motors in damp climates. By using moisture-proof windings and totally enclosed motors this trouble has been decreased. Besides lowered investments, refiners have found that outdoor and semi-outdoor plants 1) provide greater flexibility for station expansion, 2) require a smaller operating force, 3) have cleaner enclosed structures, and 4) permit better ventilation of turbine rooms. Against these advantages must be balanced the slightly higher cost of outdoor boilers and turbines.

At least $5 per installed kw. is saved in plant construction costs when using outdoor equipment. Structural costs are reduced 25 to 35 percent, representing about a 5 percent saving in total power plant cost. Outdoor boiler costs run between 1.5 and 3 percent greater than conventional units. Auxiliary equipment costs are approximately the same for indoor and outdoor installations. Some refiners have found that reduction of operating personnel to a point where boiler efficiency is reduced 2 percent or more makes outdoor installations questionable on a long term basis. Increase of operating personnel to care for outdoor installations is seldom economical because increased payrolls rapidly offset construction savings. Plant painting costs are usually slightly higher for outdoor installations. When tur-

bines are installed outdoors in light, low cost metal housings, savings in total cost amount to about 3 percent.

Important Factors

Some of the factors which outdoor plant design and operating experience have shown to be important are: 1) climatic conditions, 2) type of fuel and firing arrangement, 3) value of reliability, 4) land costs, 5) maintenance costs, 6) initial savings, 7) fuel costs, 8) required safety standards, 9) relative importance of steam and power in production, 10) type of installations—new or extension, 11) working conditions permissable in plant region, and 12) extra cost of weather resistant equipment.

Designers must provide temporary structures for maintenance work on outdoor equipment, enclose firing aisle, control room, and offices; protect exposed piping, pumps and other equipment subject to freezing, even in localities with mild winters; adequately house gage glasses, boiler drum access openings, and avoid flanged horizontal joints in fan and boiler casings; study night lighting requirements thoroughly, and specify safety valve settings for a greater differential between opening and closing pressures to prevent leakage after sudden temperature changes. By eliminating heavy turbine room structures which carry the traveling crane, designers can reduce total costs without affecting turbine operation. In place of the conventional structure, designers can 1) specify turbines designed for outdoor service, 2) use individual metal turbine enclosures, removable for major overhaul work, or 3) use a light-weight structure with access hatches in combination with an outdoor gantry crane.

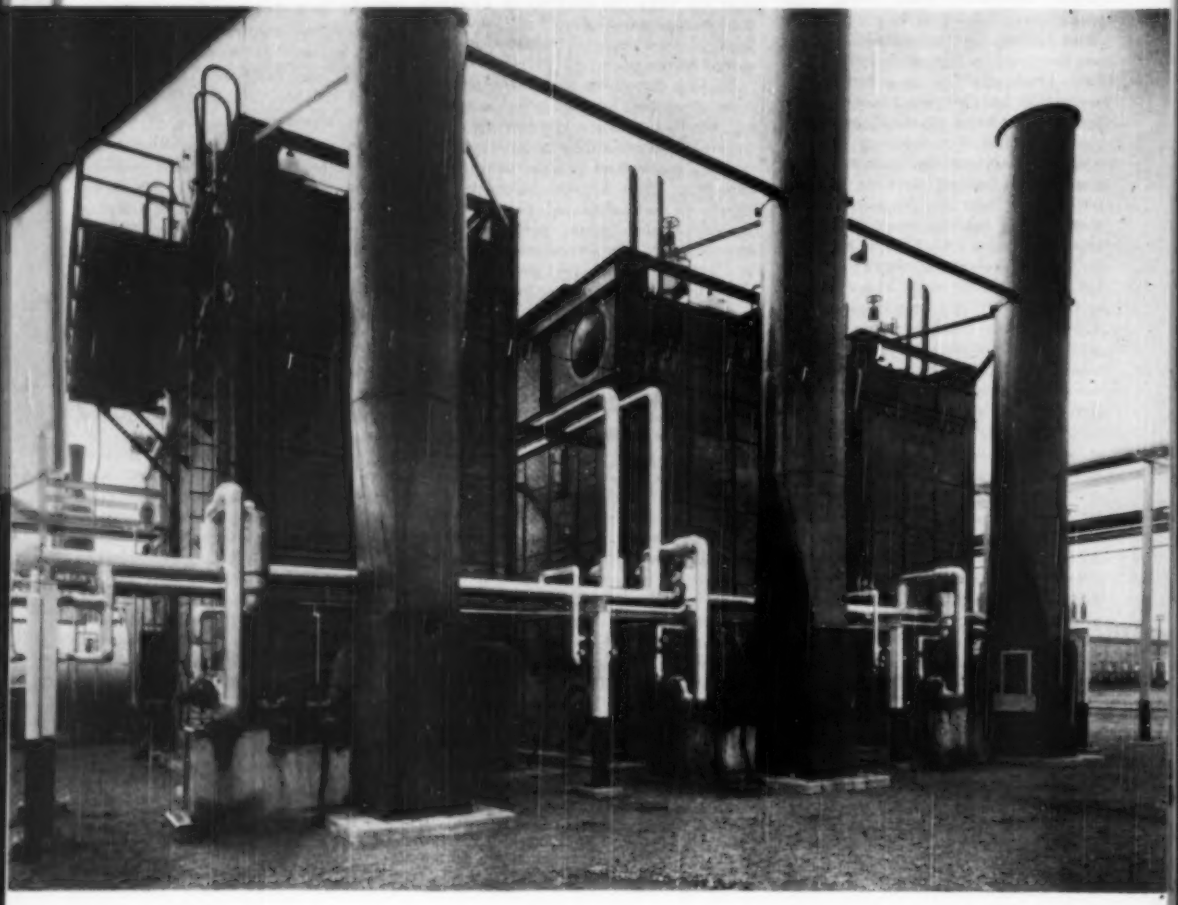
Outdoor Preference

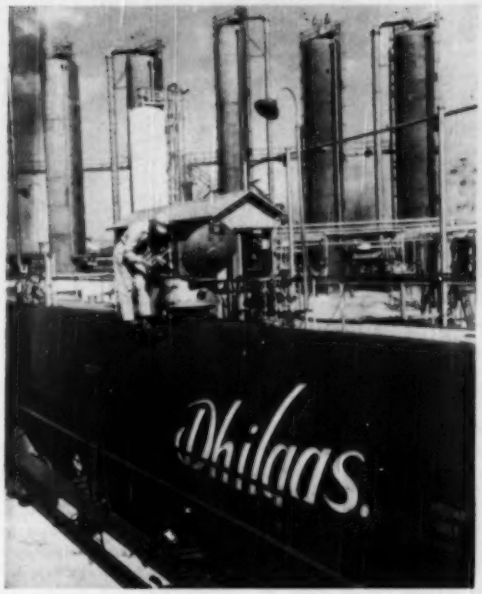
Operating men prefer outdoor plants in mild climates because working conditions are more pleasant. In colder climates some operators complain about leaving a warm turbine or control room to go outdoor in winter. In the summer, however, they prefer the outdoor type plant. The general opinion of operating men seems to be that outdoor plants are cooler, roomier, cleaner and easier to maintain.

Besides these developments, refiners have made many advancements in waste heat boilers and generation of steam from process operations. These activities will be discussed in a future article.

End of Part II. Part III will appear in an early issue.

Figure 4. Typical outdoor installation of medium capacity boilers in a refinery. Elimination of the usual boilerhouse reduces structural costs. Housings of induced draft fans in foreground are reinforced to support stacks. Photo courtesy of Green Fuel Economizer Company.





Liquefied Petroleum Gas Sales Continue to Gain

K. W. RUGH AND E. O. MATTOCKS
Phillips Petroleum Company, Bartlesville, Oklahoma

THE liquefied petroleum gas industry continued its steady growth of increased sales during the year 1949. It is estimated that during 1949 the total volume of liquefied petroleum gas marketed in the United States was 2725 million gallons. This represents an 8.5 percent increase over the volume sold in 1948.

The fact that the increase in sales volume during the year 1949 was 8.5 percent when increases during the past few years have ranged from 25 percent to 30 percent does not in itself indicate that continuing lesser percentage increases in marketed volume can be expected during the next few years. The percent increase in 1949 was low because of the mild weather in the winter of 1948-1949 in those areas where liquefied petroleum gas is used extensively for house-heating and because many new natural gas transmission lines were placed in operation during the year 1949. Some of the liquefied petroleum gas used by utilities was displaced by this new supply of natural gas. Over a period of years we can assume that normal winter temperatures and demand for liquefied gas to augment natural gas supplies during peak conditions will again create the normal increased demand for liquefied petroleum gas and the industry will again enjoy its traditional large percentage increases.

It is estimated that the volume of LPG sold for domestic purposes in 1949 reached 1650 million gallons. This represents an increase over 1948 sales of 12 percent. The demand from present consumers for additional gas appliances and the demand from new consumers for LPG for cooking, water heating, refrigeration and space heating was as much in evidence as during any previous year. The winter of 1948-1949 was relatively mild throughout wide areas in which LPG is used for space heating, which resulted in a decrease in demand for the product during the heating season; nevertheless the increased demand from new consumers together with the increased year around demand from existing consumers resulted in an appreciable increase in total demand for household use of LPG.

It is estimated that there are 6.5 million homes enjoying the use of LPG service in farm and suburban homes beyond the gas mains.

The volume of LPG used in 1949 for industrial purposes, internal engine operation and other miscellaneous industrial uses is estimated at 310 million gallons. This represents an increase over that consumed in 1948 of 0.3 percent. During 1949 many industrial plants turned to LPG for their major source of fuel. In addition, as natural gas lines were extended, making natural gas available to many industrial plants, some of these plants installed LPG standby installations to serve as the fuel supply during emergencies when the natural gas supply is interrupted, or during winter months when household and industrial plant space heating requirements cause curtailment of natural gas supplies normally available for manufacturing purposes. The continued demand for LPG for either constant use or standby use indicates a continuing expanded market for LPG to industrial plants.

For gas manufacturing purposes it is estimated that 240 million gallons were used in 1949. This represents an increase of 1 percent over the volume used for gas manufacturing in 1948. The gas manufacturing industry uses LPG in the smaller communities to make the complete sendout of gas and in the larger communities to augment manufactured or natural gas supplies during peak load conditions or to entirely replace manufactured or natural gas during emergency periods. There are approximately 400 gas manufacturing plants in the country using liquefied petroleum gas as their sole source of supply. In the larger communities where liquefied gas is used to augment supplies during peak load periods or as emergency standby, the gas companies have installed large storage for LPG. Because of the mild 1948-1949 winter the demand on the part of these utilities for LPG was not comparable with other years of normal winter weather. Now that these utilities are again connecting to gas appliances for domestic space-heating and other uses it is anticipated that the winter demands will again increase be-

AT TOP OF PAGE
Photo above shows liquefied petroleum gas tank car being gauged at refinery loading rack.

A 35-cubic-yard bottom dump earth hauler in action fueled by liquefied petroleum gas.

yond the capacity of their normal gas manufacturing facilities or natural gas supplies. This will create increased demands on the part of the gas industry for liquefied petroleum gas.

LPG is continuing to be accepted as an ideal raw material by the chemical industry for the production of chemical intermediates. A number of plants under construction or just completed in 1948 have been on stream during most of 1949. It is estimated that the LPG used by chemical manufacturers during 1949 was 525 million gallons which is an increase of 6.9 percent over that consumed in 1948.

During 1949 the use of LPG for tractor fuel was greatly accelerated. This increased use was brought about not only by the recognition of the economical and mechanical advantages from its use, but also by the development of a low cost method whereby LPG could be utilized in the conventional carburetion system interchangeable with the liquid fuel for which the engine was originally equipped. Considerable interest is being shown in the use of LPG to fuel trucks and busses on the highway, and a continuing demand exists for LPG to fuel engines in heavy duty construction and mining equipment.

Interest in safety has continued at a high level during the year. The Interstate Commerce Commission has issued new specifications governing the transportation of liquefied petroleum gas in cargo tanks (truck tanks), and portable tank containers (skid tanks). Likewise, during the year the National Fire Protection Association issued a new set of standards for the design, installation and construction of containers and pertinent equipment for the storage and handling of liquefied petroleum gases at utility gas plants. This has been issued by The National Board of Fire Underwriters as its NBFU Pamphlet No. 59. Likewise, the NFPA revised its standards for the design, installation and construction of containers and pertinent equipment for the storage and handling of liquefied petroleum gases. This was issued by the National Board of Fire Underwriters as its NBFU Pamphlet No. 58 dated March, 1949.

The quantity of liquefied petroleum gas now being marketed classifies this industry as one of the major fuel suppliers in this country. Known reserves and presently available but unrecovered volumes of LPG indicate adequate quantities for the increasing future demands.

Marketed Production of Liquefied Petroleum Gas

YEAR	TOTAL SALES		DISTRIBUTION—1000 Gallons							
	Gallons in Thousands	Percent Increase	Domestic[1]	Percent Increase	Ind. and Miscl.[2]	Percent Increase	Gas Mfg.	Percent Increase	Chemical Mfg.	Percent Increase
1922	233	...								
1923	277	24.4								
1924	376	36.0								
1925	404	7.2								
1926	465	15.2								
1927	1,091	134.6	Sale of Liquid Petroleum Gas Confined Primarily to Bottled Gas Business Priot to 1928							
1928	4,523	314.6	2,600	...	400	...	1,500	...	...	...
1929	9,931	119.6	5,900	126.9	1,500	275.0	2,500	66.7	...	...
1930	18,017	81.4	11,800	100.0	2,200	46.7	4,000	60.0	...	...
1931	28,770	59.7	15,295	29.6	7,172	226.0	6,303	57.6	...	...
1932	34,115	18.6	16,244	6.2	8,167	13.9	9,703	53.9	...	...
1933	38,931	14.1	16,626	2.3	13,987	71.3	8,318	—14.3	...	...
1934	56,427	44.9	17,681	6.3	32,448	132.0	6,298	—24.3	...	...
1935	76,855	36.2	21,380	20.9	47,894	47.6	7,581	20.4	...	...
1936	106,652	38.8	30,014	40.4	67,267	40.4	9,371	23.6	...	...
1937	141,400	32.6	40,823	36.0	62,610	*	11,175	19.3	26,792	...
1938	165,201	16.8	57,832	41.7	62,694	0.0	12,386	10.8	32,299	20.5
1939	223,580	35.3	87,530	51.4	93,723	49.4	15,435	24.6	26,892	—16.7
1940	313,456	40.2	134,018	53.1	124,482	32.8	20,285	31.4	34,671	29.0
1941	462,852	47.7	220,722	64.7	172,669	38.6	25,255	24.5	44,206	27.5
1942	585,440	26.5	303,857	37.6	197,179	14.2	31,366	24.2	53,038	20.0
1943	675,233	15.3	344,962	13.6	237,398	20.4	37,519	19.6	55,356	4.4
1944	898,071	33.0	445,617	29.2	254,590	7.3	45,879	22.3	151,985	175.0
1945	1,067,979	19.0	533,262	19.7	256,577	0.8	53,849	17.4	224,291	47.5
1946	1,410,370	32.1	758,466	42.2	253,745	—1.1	86,660	61.0	311,499	38.8
1947	2,008,262	42.4	1,150,538	51.7	274,125	8.0	169,332	95.4	414,267	33.0
1948	2,511,160	25.0	1,473,289	28.1	309,269	12.8	237,638	40.3	490,964	18.6
1949	2,725,000	8.5	1,650,000	12.0	310,000	0.3	240,000	1.0	525,000	6.9

[1] Household use plus other requirements by these customers such as irrigation pumping, tractor fuel, flame weeding, chicken brooding and similar uses. Included also is LPG sold by domestic distributors but used for industrial purposes, internal combustion engine fuel and for gas manufacturing purposes.
[2] Includes LPG sold for fueling internal combustion engines.
[3] Not comparable due to segregation of chemical manufacturing.

REMARKS: In this table total sales for all years except 1949, were obtained from U. S. Bureau of Mines reports. Distribution for the years 1931 to 1948, inclusive, was obtained from the same source. All other volumes were estimated by the writers. The total sales volume includes all LPG (propane, butane and propane-butane mixtures) when sold as such. Until 1944 the sale of pentane when sold for any purpose other than motor fuel blending was included. Since then it has been excluded. It does not include butane when blended with heavier petroleum fractions for motor fuel purposes. Intercompany sales transactions such as purchases of LPG by one company from other companies and resold as LPG have been eliminated in order to avoid duplication of sales figures. The data do not reflect sales of LPG used directly by the producer at the point of production for fuel polymerization, solvent de-waxing, etc. Neither do the figures include sales of hydrocarbons to plants manufacturing synthetic rubber or aviation gasoline or their components.

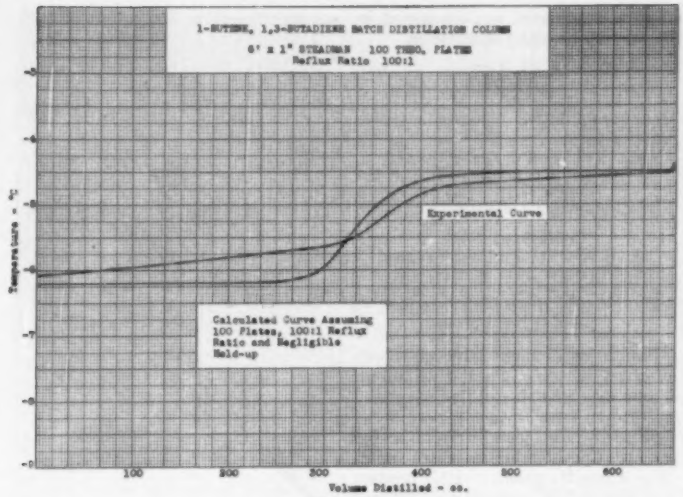


Figure 1.

LABORATORY men dealing with petrochemicals frequently encounter problems of analysis and of product separation where they must decide between the use of batch or of continuous distillation apparatus. The same choice also must be made in many commercial operations involving small feed quantities, or influenced by other considerations that suggest batch distillation. This article compares operating factors and results obtained with the two methods. It may thus provide assistance for a choice that is often difficult.

BATCH DISTILLATION— Characteristics and Limitations Of a Batch Still

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BATCH distillation is used both in the laboratory and on a commercial scale to separate multicomponent mixtures into their several components. Such distillations are carried out either to get pure cuts of the components or to make an analysis of the mixture.

In cases where analysis is the objective, a batch distillation usually does a pretty good job, at least in cases where the boiling points of the liquids are not too close together. By standardizing the procedure on a known sample, fairly good analyses can be made even in cases where the still does not give a sharp, clean-cut separation.

For the separation of pure samples from a liquid mixture by batch distillation, the results are not always so satisfactory. When the separation is a difficult one, product of high purity is seldom obtained, and if good product is obtained, the yield is usually very low.

In many cases a batch still gives less complete separation than a continuous still. For the sake of comparison, let us assume a standard column which is fitted with a small reboiler and a feed connection at the proper point for continuous operation; and an

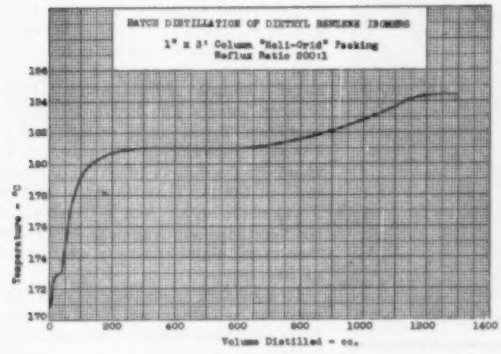
BATCH DISTILLATION OF DIETHYL BENZENE ISOMERS
1" x 3' Column "Heli-Grid" Packing
Reflux Ratio 200:1
Temperature - °C
Volume Distilled - cc.

Figure 2.

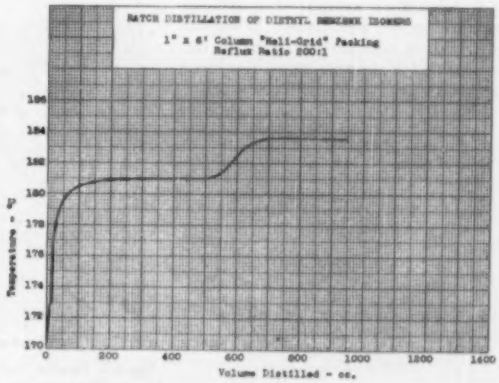
BATCH DISTILLATION OF DIETHYL BENZENE ISOMERS
1" x 6' Column "Heli-Grid" Packing
Reflux Ratio 200:1
Temperature - °C
Volume Distilled - cc.

Figure 3.

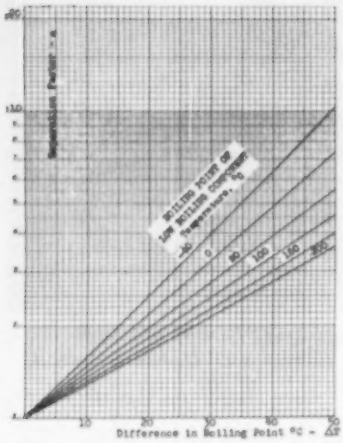

Figure 4. Paraffin Hydrocarbons, Relation between Difference in Boiling Point, ΔT and Separation Factor, α. Pressure = 760 mm. Hg.

identical column attached to a large kettle for batch operation. Qualitatively one may summarize the usual characteristics of the two still as follows:

Continuous Still—Gives theoretical separation (after allowance for plate efficiency) at near minimum reflux ratios with intermediate cut equal to hold-up per plate times the number of plates.

Batch Still—Gives less than theoretical separation at reflux ratios well above minimum, large intermediate cut, and a poor yield of good material.

The examples shown below will suffice to indicate the extent and nature of the difficulties in preparing pure samples by batch distillation. It is evident that the same or equivalent columns give better separation when used in a continuous still and that even in batch stills the results frequently fall short of what simplified calculations would predict.

A laboratory sample of a silicone mixture needed purification to remove low boiling components. A batch distillation gave unsatisfactory results; a continuous still gave better results.

Batch Still

Column — 3"x6' (¼" helicies)
No. of plates = 10 to 12
Reflux Ratio — 10 : 1
Charge — 65% of desired product
Yield — 30% of desired product of marginal purity

Continuous Still

Column — 3"x6' (½" Berl Saddles)
No. of plates = 10 to 12
Reflux Ratio — 10 : 1
Charge — 65% of desired product
Yield — 85% of desired product of good quality

In another case purification of some crude acetophenone was attempted in the laboratory using distillation.

Batch Still

Column — 1"x3' Podbielniak "Heligrid"
No. of Plates = 75
Reflux Ratio — 25 : 1
Yield — 93.5% of theoretical as 18.5° C. melting point product but only a 37.5% yield of 19.0° C. melting point product

Continuous Still

Colu..an ..4"x15' (¼" Berl Saddles)
No. of Plates = 24 to 30
Reflux Ratio — 20 : 1
Yield — 90% of theoretical as 19.5° C. melting point product

Similar advantages have also been observed in some plant distillations. In one case a batch still had been used to remove both a small percent of ... ends and heavies from a by-product. Considerably increased capacity and equally good or better product was obtained by operating the column as a continuous stripping still to take the light ends overhead until the batch kettle was full, and then shutting off the feed and continuing the separation by conventional batch distillation.

Some additional examples will show comparison between some actual and calculated results on batch stills. Figure 1 shows the separation obtained in a batch distillation of a mixture consisting principally of 1,3-butadiene and 1-butene in approximately a 50/50 mixture. This distillation was made using a 6-foot column of 1-inch Stedman packing—equivalent to about 100 theoretical plates—and a reflux ratio of at least 100:1. In this distillation even the first cut on the butylene plateau had more than 10 percent butadiene as determined by maleic anhydride analysis, and only near the the end of the butadiene fraction did

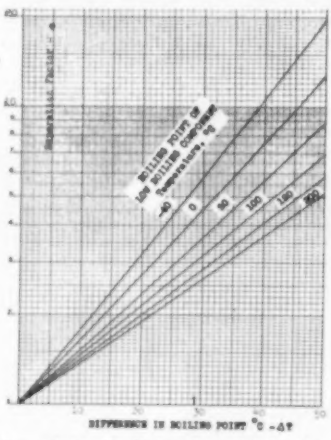

Figure 5. Paraffin Hydrocarbons, Relations between Difference in Boiling Point, ΔT and Separation Factor, α. Pressure = 100 mm. Hg.

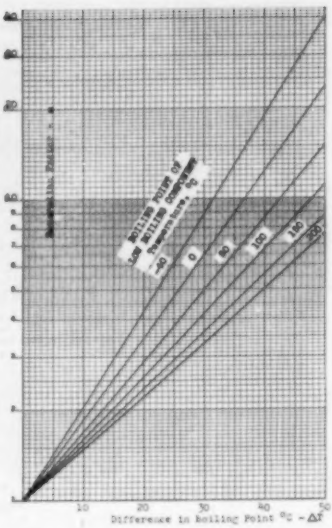

Figure 6. Paraffin Hydrocarbons, Relation between Difference in Boiling Point, ΔT and Separation Factor, α. Pressure = 10 mm. Hg.

the product approach 99 percent purity.

Plotted along with the experimental curve is the curve calculated on the basis of the Rose equation,[2] assuming negligible hold-up in the column. In actual practice, continuous commercial columns, operating on about the same sort of feed material and using a reflux ratio less than 50:1, yield butadiene with an overhead purity of more than 99 percent and relatively small loss of butadiene out of the bottoms.

Another example, which indicates that the separation of two or more components by batch distillation may be far from complete or sharp, involves distillations of diethyl benzene isomers. M-diethyl benzene boils about 2.6° lower than either of the other two isomers and hence should show an α-value of at least 1.06. Figures 2 and 3 show typical distillation curves on two different mixtures, the chief component of which is m-diethyl benzene, the other materials being a few percent of butyl benzene and somewhat larger quantities of the o- and p-diethyl benzene isomers. The distillation shown in Figure 2 was made on a 3-foot x 1-inch Heli-Grid column equivalent to about 75 theoretical plates at a reflux ratio of 200:1. That shown in Figure 3 was made on a 6-foot x 1-inch Heli-Grid column—equivalent to about 150 theoretical plates—using a reflux ratio of 200:1.

It is evident from these curves that even the separation of butyl benzene from m-diethyl benzene—difference in boiling point = 7.0° C. ($\alpha = 1.2+$)—does not give a sharp separation.

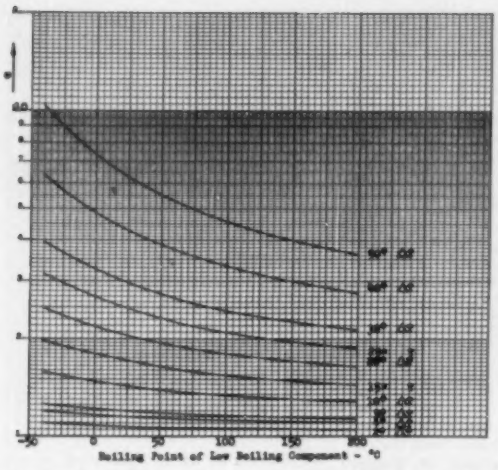

Figure 7. Paraffin Hydrocarbons, Relation between Temperature and α at Different ΔT's. Pressure = 760 mm Hg.

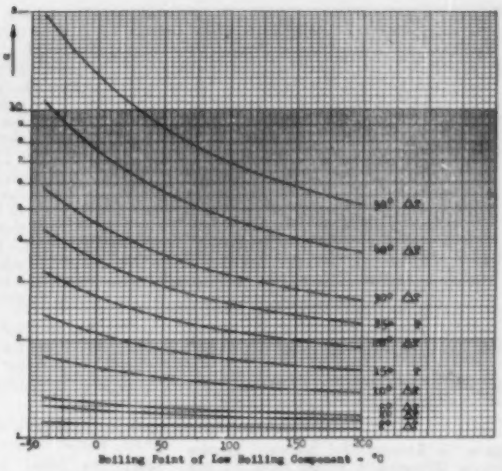

Figure 8. Paraffin Hydrocarbons, Relation between Temperature and α at Different ΔT's. Pressure = 100 mm Hg.

As can be seen from Figure 3, the amount of butyl benzene impurity in the overhead product was sufficient to lower the boiling point of the mixture when 200 cc. of the 1200 cc. charge had been distilled over. Although there were only 2 percent of the butyl benzene in the original mixture, at least 20 percent of the mixture had to be distilled away before substantially butyl-benzene-free product was produced.

Study of the curves in Figures 2 and 3 also indicates that the curves for the diethyl benzene isomers deviate from the plateau for considerable distance both before and after the inflection point.

These examples are characteristic of the general experience in batch distillations particularly where the α-value is, say, 1.25 or less.

In order to judge what one may legitimately expect from a given batch still, and in order to decide how to obtain optimum results, it will be desirable to consider the factors which influence the results obtained.

Factors Affecting the Degree of Separation in a Batch Distillation

If uniform operating conditions are maintained, the following are the basic factors which determine the results to be obtained in any given distillation on a batch still:

Separation Factor — α
Number of Plates — n
Reflux Ratio — R
Plate Efficiency
Hold-up

1) *Separation Factor*

It is obvious, first of all, that the sharpness with which any two components can be separated in a batch still is dependent upon the ease with which they can be separated, i.e., on the difference in their boiling points, or more exactly on the value of separation factor, α. If α is large, the separation is easy and a sharp break may be expected in the batch distillation curve. For smaller α's, approaching 1 as a limit, the separation becomes progressively more difficult. For ideal mixtures of two components, α is given by equation (1).

$$\alpha = \left.\frac{p_s}{p_t}\right]_T \qquad (1)$$

Where, p_s and p_t = vapor pressures of the low boiling and high boiling components respectively. For a complex or non-ideal system, α is given by equation (2).

$$\alpha = \left.\frac{k_2}{k_1}\right]_T \qquad (2)$$

where

$$k_1 = \left.\frac{y_1}{x_1}\right]_T \qquad k_2 = \left.\frac{y_2}{x_2}\right]_T$$

Where,

x_1 = molar concentration of the high boiling component in the liquid phase.

y_1 = molar concentration of high boiling component in the vapor phase.

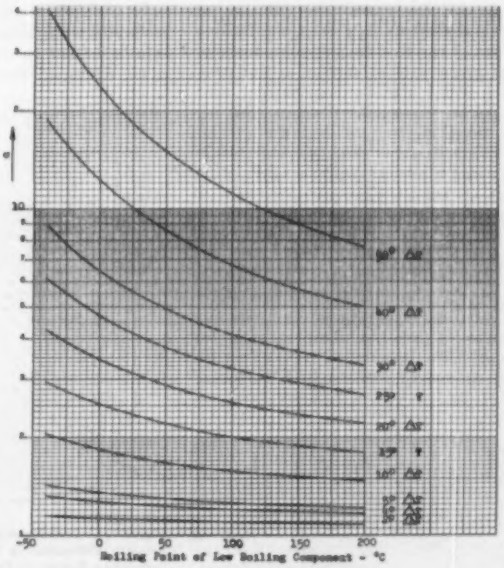

Figure 9. Paraffin Hydrocarbons, Relation between Temperature and α at Different ΔT's. Pressure = 10 mm Hg.

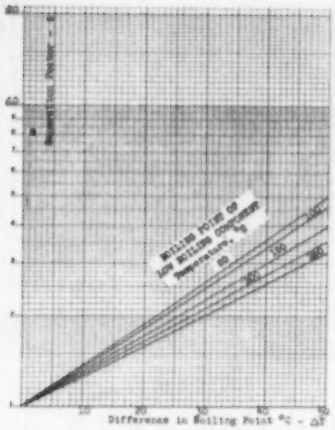

Figure 10. Benzene-Alkyl Benzenes, Relation between Difference in Boiling Point, ΔT and Separation Factor, α. Pressure = 760 mm. Hg.

x_d & y_d are the corresponding concentrations for the low boiling components.

It will be noted that α is a function of the difference in vapor pressure of the two components at a given temperature. α can be related to the difference in boiling point of the two materials through their vapor pressure curves. When relating α to difference in boiling point, one must take into account both the pressure on the system and the boiling points of the materials at this pressure. The families of curves in Figures 4, 5, 6, 7, 8 and 9 show α plotted against ΔT for the paraffin hydrocarbons. Figures 10, 11, 12, 13, 14 and 15 show α plotted against ΔT for the alkyl benzenes. In these sets of curves the families of lines represents T_1's (i.e., the boiling point of the low boiling component of the given pair of liquids at the pressure of the system under consideration.

An example will illustrate the use of these charts. To find the α-value for 2,2-dimethyl butane (B.P. 49.7° C.) and 2-methyl pentane (B.P. 60.2° C.) at atmospheric pressure, turn to Figure 4, move down the 50° line to a ΔT of 10.5° and read the α-value directly—$\alpha = 1.43$.

Data for vapor pressure to calculate α can be obtained from a Cox chart. Where the Cox chart constants are known it may be simpler and, for small ΔT's, is more accurate to use the equation developed by R. S. Spencer.[3]

$$\log \alpha = \log \frac{P_x}{P} \Big/ \left[\left(\frac{T+T_x}{T_x-(T+T)}\right)\left(\frac{T_x}{T}-1\right)-1\right] \quad (3)$$

P_x = The pressure for the infinite point (point of intersection) for the given Cox chart family.

where, $P_x = 1.3 \times 10^8$ mm Hg. for paraffins

$P_x = 2.0 \times 10^8$ mm Hg. for alkyl benzenes

P = The pressure on the system, (760 mm Hg. for the illustration cited above)

$T = t + 230$

t = Boiling temperature under consideration (100° C. in the above illustration)

T_x = The temperature for the infinite point (point of intersection) for the given Cox chart family.

$T_x = 1240° C. + 230° C.$ for paraffins

$T_x = 1500° C. + 230° C.$ for alkyl benzenes

A word of caution should be entered here. These values have been calculated for ideal mixtures of binary systems. For liquid pairs that do not form an ideal mixture or for multi-component systems, α-values may need to be determined from experimental data.

It will be noted that α is an inverse function of pressure; i.e., within any one family, α increases as the pressure decreases. Thus, the separation factor, α, is more favorable for vacuum distillations of homologues. When separating two materials from different Cox Chart families, the vapor pressure curves may not diverge at lower pressures; in fact, they may actually converge. When the latter is true, the α-value decreases with decreasing pressure. Fortunately, this is not the usual case.

The above relationships for α refer only to cases of ideal mixtures. Any deviation from ideality will make the liquids harder to separate by distillation. When a laboratory distillation

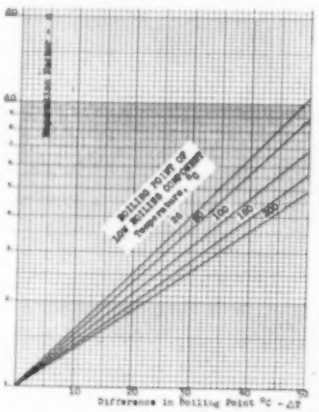

Figure 11. Benzene-Alkyl Benzenes, Relation between Difference in Boiling Point, ΔT and Separation Factor, α. Pressure = 100 mm. Hg.

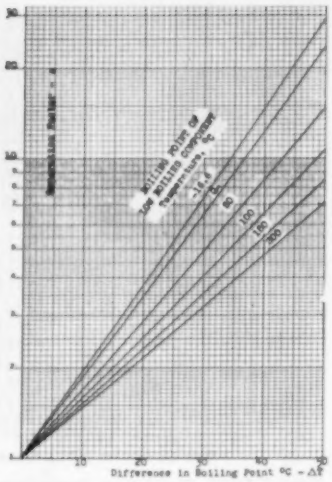

Figure 12. Benzene-Alkyl Benzenes, Relation between Difference in Boiling Point, ΔT and Separation Factor, α. Pressure = 10 mm. Hg.

proves disappointing, it may be due to deviation from ideality.

2. *Number of Theoretical Plates Required*

The number of plates in the column of a batch still is another important factor in the sharpness of separation. For any pair of liquids with a given α-factor, a minimum number of theoretical plates are required for any given degree of separation. Equation (4) shows the relation between total degree of separation, "E," and the number of plates, "n."

$$E = \alpha^n \quad (4)$$

"E" may be defined more specifically as in equation (5),

$$E = \left(\frac{x_D}{1-x_D}\right)\left(\frac{1-x_B}{x_B}\right) \text{ where,} \quad (5)$$

x_D = molar concentration of component x in the distillate,

x_B = molar concentration of component x in the bottoms.

By combining equation (4) and (5) and eliminating "E," one obtains the Fenske equation:

$$\left(\frac{x_D}{1-x_D}\right)\left(\frac{1-x_B}{x_B}\right) = \alpha^n \quad (6)$$

Figures 16, 17, and 18 show the relationship between the number of plates required to give a purity of 99.5 percent overhead and 99.5 percent bottoms at total reflux for the paraffin hydrocarbons. Figures 19, 20, and 21 give similar curves for the benzene-alkyl benzene family. These

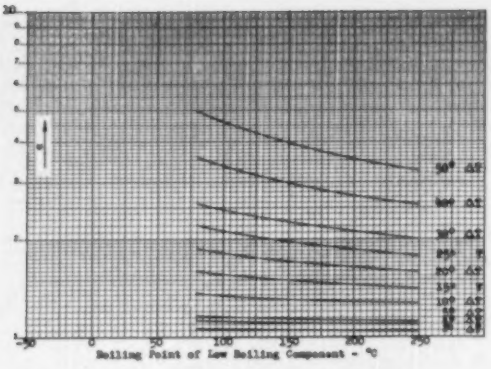

Figure 13. Benzene-Alkyl Benzenes, Relation between Temeprature and α at Different ΔT's. Pressure = 760 mm Hg.

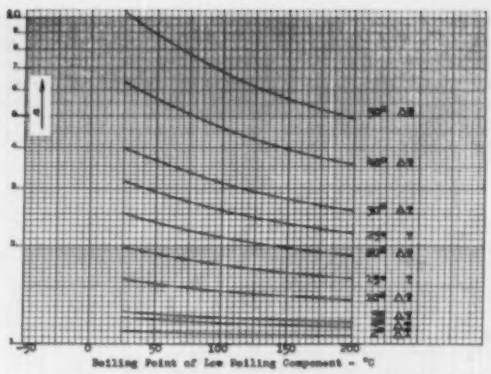

Figure 14. Benzene-Alkyl Benzenes Relation between Temperature and α at Different ΔT's. Pressure = 100 mm Hg.

curves have been calculated from the α-values used for Figures 4 to 15, for the case of total reflux. In these figures the families of curves are for T_1's, i.e., the boiling point of the low boiling component of the given pair of liquids at the pressure of the system under consideration.

From these curves, one may obtain a rough idea of the minimum number of plates to give a specified separation.

For the case where the reflux ratio is finite and approximately equal to the number of plates in the column, one might expect the given separation to require about 50 percent more plates than the minimum number indicated.

3. *Reflux Ratio*

The degree of separation for any pair of liquids by a still is also a function of the reflux ratio, "R". Even with an infinite number of plates, there is a minimum reflux ratio below which a given separation is impossible. The effect of a reflux ratio on a batch still can best be visualized from a McCabe-Thiele diagram. A study of Figure 23 reveals that the operating line (reflux line) crosses the vapor-liquid equilibrium line at some finite value for x mole fraction of the low boiling component in the kettle. The larger the reflux ratio, the larger is this value of x. It is also evident from this diagram that the concentration of the low boiling component in the kettle can never be reduced below this value of x as long as the overhead purity is maintained. In other words, the reflux ratio fixes the kettle composition with respect to low boiler when the overhead product begins to enter the intermediate fraction. Figure 22 shows the reflux required to maintain an overhead purity of 99.5 mol percent at different kettle compositions.

The above considerations apply to the limiting case of minimum reflux, i.e., infinite plates. In any actual still with a finite number of plates, more reflux will be required to get a given separation. Rose[4] has pointed out that in general, for a batch still, the reflux ratio may well be chosen about equal to the number of plates, $R = n$, and that the practical limits are given by

$$R = 2/3n \quad \text{to} \quad R = 3/2n$$

Figure 24 gives a plot of the relationship given by Rose.

It is interesting to trace on a McCabe-Thiele diagram the progress of a distillation from one component through the intermediate fraction to the next higher boiling component. Let us assume a batch distillation of a 50/50 mixture of toluene and ethyl benzene, using a column with 10 theoretical plates and a 10:1 reflux ratio. Figure 25 shows an idealized distillation curve for such a mixture. Figures 26, 27, 28, 29 and 30 illustrate the relation of reflux ratio, plates and composition at different stages of distillation. The numbers in the circles in Figure 25 refer to the McCabe-Thiele Figure representing that state in the distillation.

The McCabe-Thiele diagrams are based on:

Assume Raoults Law
Et. Benzene ..... B.P. = 136.16° C
Toluene ..... B.P. = 110.6
Δt = 25.56
α110° C = 2.13
α130° C = 1.98
10 Equivalent Theoretical Plates
10:1 Reflux Ratio
x_D = Mole fraction Toluene in distillate
x_B = Mole fraction Toluene in kettle

Figure 26 shows that at the begin-

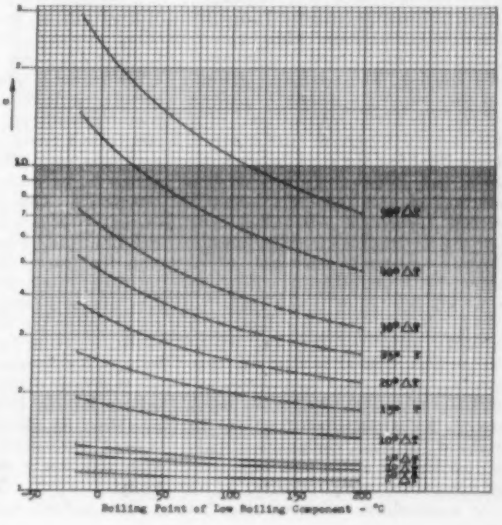

Figure 15. Benzene-Alkyl Benzenes Relation between Temperature and α at Different ΔT's. Pressure = 10 mm. Hg.

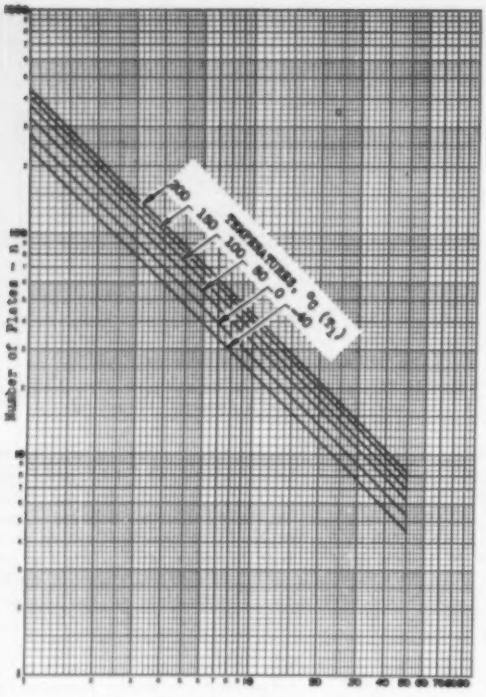

Figure 16. Theoretical Plates Required to Separate Paraffins at 760 mm Hg. and Total Reflux to 99.5 Mol Percent Purity.

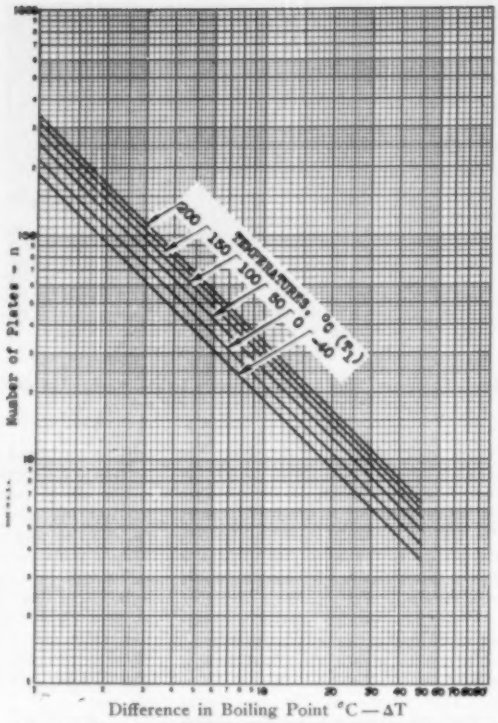

Figure 17. Theoretical Plates Required to Separate Paraffins at 100 mm Hg. and Total Reflux to 99.5 Mol Percent Purity.

ning of the separation, when the kettle composition is 50/50, the ten plates are enough to yield an overhead purity of about 99.8 mol percent benzene. Figure 27 shows the construction when 1/4 of the charge has been distilled. The product purity has dropped to about 99 percent and the kettle composition is about 25 mol percent x_n. Figure 28 shows the compositions when the distillation begins to enter the intermediate fraction. The product composition has dropped to about 95 percent and x_n, the kettle composition, to a little over 10 percent low-boiler. Figure 29 shows the construction midway in the intermediate cut. At this point x_n has been reduced to about 5 percent. Figure 30 shows that even after the intermediate fraction has distilled off and the product has only 5 percent low-boiler, there is still about .5 percent low-boiler in the kettle.

It is obvious from this that, at a set reflux ratio, the overhead purity will decrease slowly at first and then more rapidly as one approaches the break and that as the distillation passes through the intermediate fraction, the overhead product composition only approaches that of the pure high boiling component asymptotically.

As a correlary, one may note that for a given overhead purity, the reflux ratio may be small at the start of a distillation and progressively increased as one approaches the break. This method of operation reduces overall distillation time and the amount of heat required for a given distillation but does not give as high average product purity as using the higher reflux ratio throughout.

4. *Plate Efficiency*

The matter of plate efficiency is frequently neglected by the laboratory man in considering what he should expect from a given column. Actual data show that plate efficiency may be expected to be nearer 50 percent than 100 percent. One good generalization on plate efficiency is that of Drickamer and Bradford.[2] Figure 32 shows their empirical curve relating molal average viscosity and plate efficiency which they obtained using such data as they could find in the literature in addition to data on about 100 columns operated by several refineries. The authors point out that their data include only hydrocarbon liquids. Dow data on columns operating on alkyl-benzene and chlorinated derivatives show indications that this curve also fits for these liquids.

The authors note that this curve appears to hold only for columns up to 5 or 6 feet in diameter. Beyond that point allowance must be made for increased efficiency due to cross-flow on the plates.

The fact that viscosity increases with decrease in temperature and that plate efficiency decreases with increased viscosity indicates that the plate efficiency should be lower for a given pair of liquids when distilled under vacuum than when distilled at atmospheric pressure. Thus, some of the gains from an increased α at low pressures may be off-set by a decreased plate efficiency.

This data on plate efficiency is of particular importance when considering bubble-cap plant columns and Brunn bubble-cap or Oldershaw sieve-plate laboratory columns. As a rough approximation, one may assume for these columns, say, 50 percent plate efficiency. Thus, a 10-plate Brunn bubble-cap column represents more nearly five theoretical plates.

On packed columns, the matter of plate efficiency is partly taken care of in the measurement of h.e.t.p. (heighth equivalent theoretical plate). It is customary to determine the number of plates in a given packed column

by an actual run on some standard pair of liquids. Thus, the plate efficiency is already taken into account. Some other pair of liquids, may, however, have a different average viscosity and thereby give a different plate efficiency; hence, a different h.e.t.p. For example, compare n-heptane-methyl cyclohexane and benzene-thylene dichloride test mixtures:

MATERIAL	Viscosity	Plate Efficiency (As read from graph) (Figure 32)
(a) n-heptane	2.0	
Me.-cyclohexane	3.2	
50/50 mixture	2.6*	53%
b) Benzene	3.1	
Ethylene dichloride	4.2	
50/50 mixture	3.65*	43%

* These viscosities are those for the boiling point temperature of the 50/50 mixture.

Similarly, one can determine the approximate effect of temperature on viscosity and plate efficiency.

m-Diethyl Benzene

Pressure	Boiling Point	Viscosity	Plate Efficiency
740 mm.	180° C.	2.25	56%
58 mm.	100° C.	4.00	42%
10 mm.	60° C.	6.00	31%

Thus, a change from atmospheric pressure to 58 mm. pressure represents a 25 percent reduction in plate efficiency and to 10 mm., a 45 percent decrease; and requires increases of 25 percent and 45 percent respectively in column height to give the same degree of separation—less, of course, some gain due to increase in α.

5. *Effect of Hold-up*

The factors which have been discussed up to this point deal with the nature of the liquids to be separated and the characteristics of the column itself, and shed no light on the difference between a batch still and a continuous still. The important factor which has not yet been discussed is hold-up; herein must lie the main difference between batch and continuous distillation.

In the case of a continuous still, a steady state is reached and hold-up cancels out. If a given size batch of a two-component mixture is to be separated by a continuous still, the quantity of mixed fraction at the end of the run will be only the hold-up per plate times the number of plates provided, of course, the products are recycled at the beginning of the run until the still has reached equilibrium.

In the case of a batch distillation, however, the concentration at any point in the system is constantly changing with time and hold-up does not cancel out. The intermediate fraction bears no simple relationship to the hold-up per plate times the number of plates. It is more directly related to the ratio between the total charge and the hold-up in the column.

Just what is there about the arrangement of having the total charge contained in the kettle at the bottom of the column, which handicaps the column and prevents it from giving the separation which might be expected by continuous operation? Is it the lack of equilibrium—the fact that the column does not reach a steady state? This apparently is not the trouble, because as will be pointed out below, when a column is operated in batchwise fashion with a very small charge, quite sharp breaks are obtained even with liquids which are difficult to separate.

There are a number of evidences

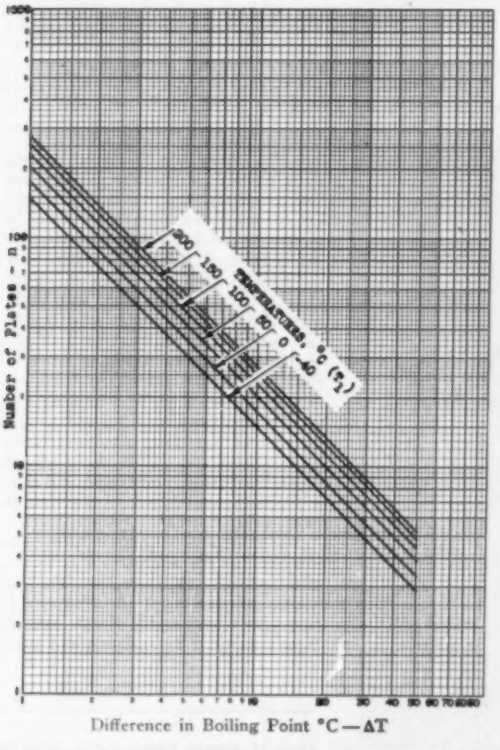

Figure 18. Theoretical Plates Required to Separate Paraffins at 10 mm Hg. and Total Reflux to 99.5 Mol Percent Purity.

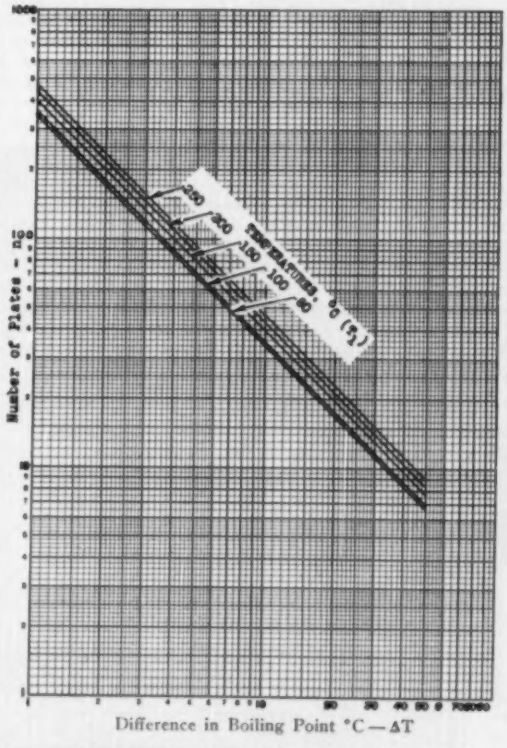

Figure 19. Theoretical Plates Required to Separate Alkyl Benzenes at 760 mm Hg. and Total Reflux to 99.5 Mol Percent Purity.

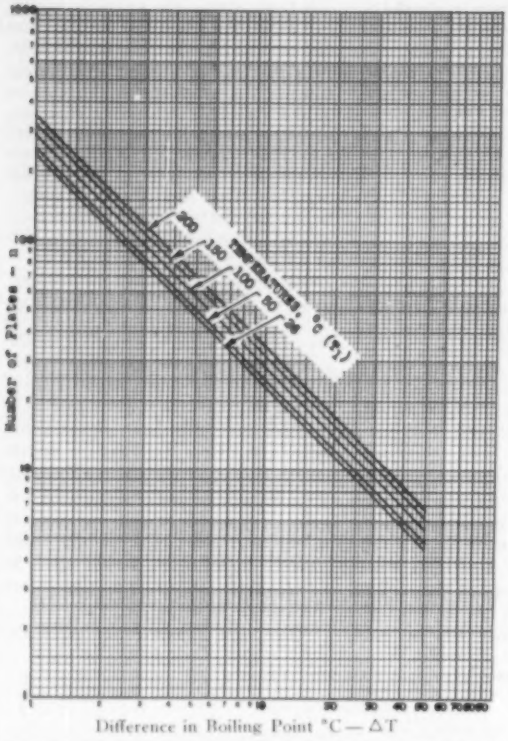

Figure 20. Theoretical Plates Required to Separate Alkyl Benzenes at 100 mm Hg. and Total Reflux to 99.5 Mol Percent Purity.

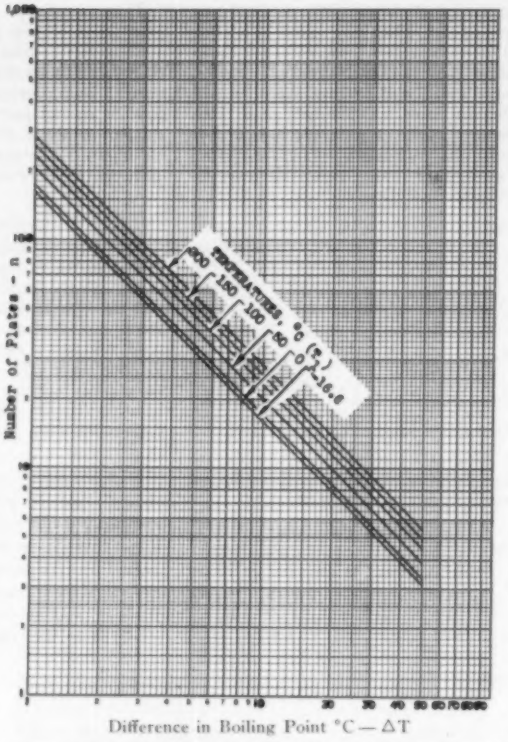

Figure 21. Theoretical Plates Required to Separate Alkyl Benzenes at 10 mm Hg. and Total Reflux to 99.5 Mol Percent Purity.

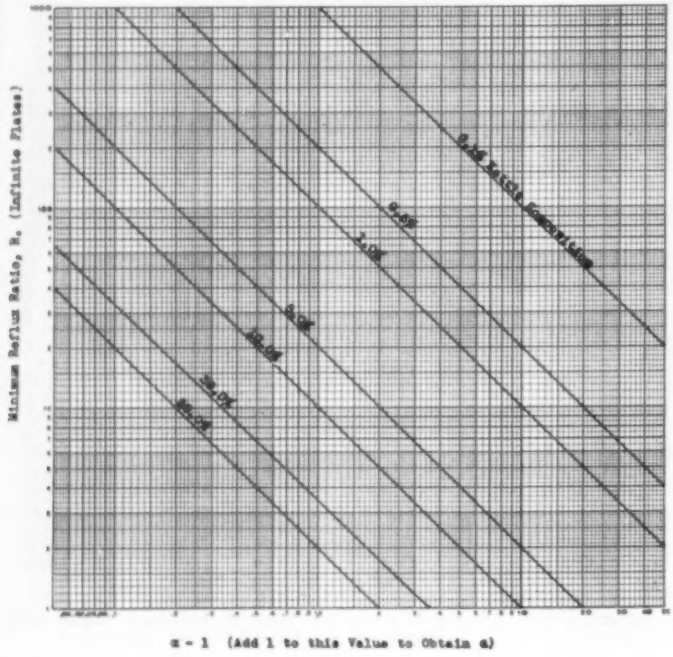

Figure 22. Relation between Reflux, Alpha and Composition of Kettle for Binary Mixtures with Constant Overhead Purity of 99.5 Mol. Percent.

that the size of the charge in the kettle is of major importance in determining the sharpness of the separation. For example, repeated observations on laboratory distillations indicate that the separation will be sharper when the break comes near the end, rather than when it comes near the beginning of the distillation. In other words, the separation is sharper if the amount of material in the kettle is small at the time of the transition from one fraction to another. The limiting case in reducing the size of the still charge consists of operating a column batchwise without any kettle. Such experiments have been performed and show a much sharper break in the distillation curve.

The Podbielniak Company developed a technique for analyzing C_4's by distillation using this principle. The conventional analytical distillation did not give a noticeable break between 1-butene and 1,3-butadiene and could

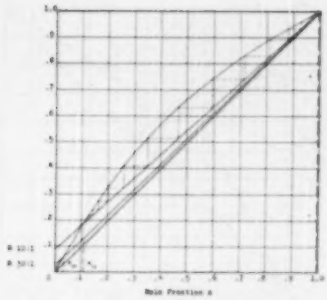

Figure 23. Toluene-Ethyl Benzene System. McCabe-Thiele Diagram.

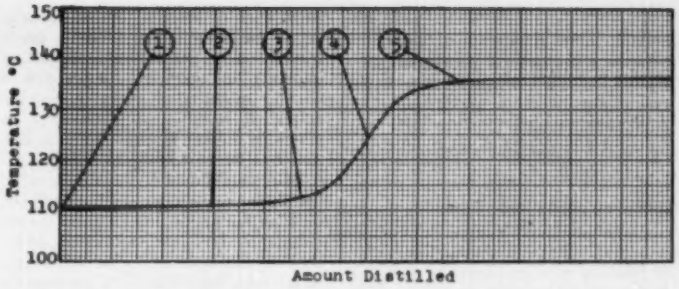

Figure 25. An Idealized Batch Distillation Curve for a 50/50 Mixture of Toluene and Ethyl-Benzene. The circled numbers indicate the stages illustrated by the next five figures. The McCabe-Thiele diagrams are based on:

Assume Raoults Law

Et. Benzene	B. P. =	136.16° C.
Toluene	B. P. =	110.6
	Δt =	25.56

α110° C. = 2.13
α130° C. = 1.98
10 Equivalent Theoretical Plates
10:1 Reflux Ratio

X_D = Mole Fraction Toluene in Distillate
X_b = Mole Fraction Toluene in Kettle.

not be used to analyze for the C_4 components. In The Podbielniak Company's laboratory, a gas sample so small that it would all be contained in the column under distillation conditions was distilled on a high efficiency Heli-Grid packing. A high boiling chaser was used to conduct heat. By this method, a sufficiently sharp break between 1-butene and 1,3-butadiene was obtained to permit analysis to within 1 percent accuracy on a 50/50 mixture.

At The Dow Chemical Company small samples of liquid mixtures have been distilled over a 6-foot Heli-Grid packed column. The intermediate fraction was only 1/6th as much when a 75 cc. sample was used as when 1000 cc. of the same material was distilled under the same conditions.

In the fundamental batch distillation equation, there are no terms which indicate a relation between the size of the intermediate fraction and the hold-up per plate in the column. Hold-up comes into the equation as a ratio between the size of the still charge and the total column hold-up. The equation indicates that sharper breaks should be obtained when the total charge is small. In general, this is borne out by experience. Tests reported by Colburn and Stearns[1] show that for certain conditions the break was sharper for the experimental curve than for one calculated for no column hold-up. They also noted that when the column hold-up was large compared to the total charge the sharpness of the separation was less affected by low reflux ratios. Their data indicated that under some conditions of column hold-up, size of charge, reflux ratio, number of plates, ease of separation, etc., the operating line for a batch still, as plotted on a McCabe-Thiele diagram, may not be a straight line and that a given separation may be obtained with less plates or less reflux than is predicted by theory.

In normal batch distillation the shape of the "break" in the distillation curve is not symmetrical. A more abrupt transition from good overhead product to intermediate fraction is obtained on the lower half of the "break." As the distillation passes through the "break" the product approaches pure high-boiler asymptotically and for difficult separations, considerable high-boiler must be distilled over before product, substantially free from low-boiler, is obtained. If, as is usually the case, a high-boiling impurity is also present, only a low yield of good product may be obtained before some of the high-boiling impurity begins to come over in the product. This is a more serious problem than is generally supposed for most chemical reactions are apt to produce a few per cent of some low-boiling impurity, and even a good batch distillation may not remove all of it.

A common error regarding batch distillation is the supposition that if a 1000-cc. sample containing 800 cc. of a desired component yields only 100 cc. of this component of the desired purity, a 2000-cc. sample when distilled under the same conditions will yield 900 cc. of good product. Such is not the case. The larger sample will give about the **same percentage of good product,** namely about 200 cc. of good product.

Experimental data and theory indicate that the larger the batch still

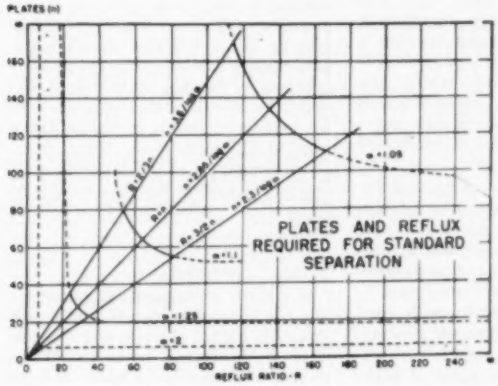

Figure 24. Reproduced by permission from the Original Publication in Industrial Engineering Chemistry.

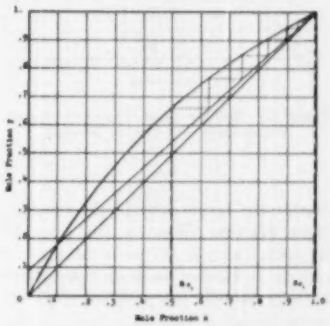

Figure 26. Toluene-Ethyl Benzene System. First Stage—50/50 Mixture.

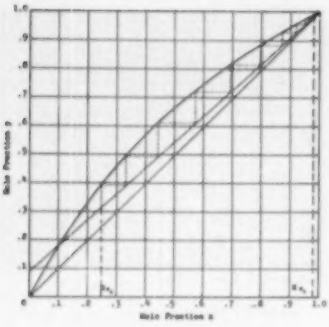

Figure 27. Toluene-Ethyl Benzene System. Second Stage—25 Percent Distilled.

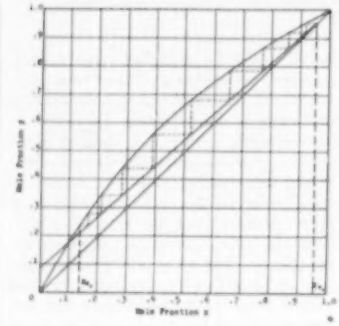

Figure 28. Toluene-Ethyl Benzene System. Third Stage—40 Percent Distilled.

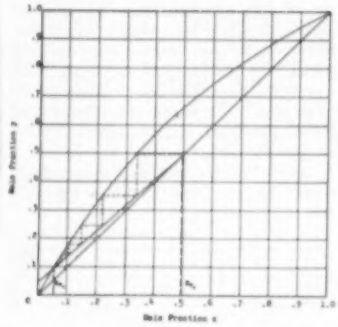

Figure 29. Toluene-Ethyl Benzene System. Fourth Stage—25 Percent Distilled.

charge the larger will be the intermediate fraction. What is the physical meaning of this influence of size of charge on the sharpness of separation? It may simplify the problem if we remind ourselves that the reboiler is the first plate in the still—a plate with very large hold-up in the case of a batch still. When the portion remaining in the kettle is large, even a small fraction of a percent of low boiling impurity in the kettle represents a sizeable quantity of material. For example, if one liter of materials remains in the kettle when the composition has been reduced to 0.5 percent low-boiler, there still remains 5 cc. of low-boiler to be removed from 995 cc. of high-boiler. If the hold-up in the column is 1 cc. per equivalent plate, then a thousand times as much material must interchange to remove the low-boiler from the kettle as would be required to remove low-boiler of the same concentration from one of the plates in the column. Perhaps this volume in the kettle is the chief handicap which prevents the column in a batch distillation from making as sharp a separation as it otherwise would.

Type of Still vs. Separation Required

Since the large quantity of material in the kettle of a batch still places a certain handicap on the column, and since the conventional batch still is only one of five different ways in which a column may be used for distillation, the operator needs to be sure that he is using the right type of still to do the job which he requires. To select the right type of still he must consider the advantages and limitations of each of the following:

1 Batch rectifying still
2 Batch stripping still
3 Continuous rectifying still
4 Continuous stripping still
5 Continuous still with both rectifying and stripping sections.

Each of these stills shows advantages in certain cases; the problem is to fit the still to the job. **All too frequently the batch still has been used for jobs for which it is not suited.**

1 *Batch Rectifying Still*

The conventional batch still uses the column as a rectifying section. It does a good job of rectifying but a poor job of stripping.

The batch still will usually give fairly satisfactory analysis of a multicomponent mixture of liquids especially if the apparatus is calibrated against a known mixture.

The batch still is a good tool for separating a multicomponent mixture into fractions containing each of the several components **provided a high degree of purity is not required.** The batch still is not a good tool to get product of high purity with good yield from a multicomponent mixture.

The batch rectifying still is an efficient way to remove traces of high-boiler from a single lower boiling component. For this it will give a sharp, cleancut separation.

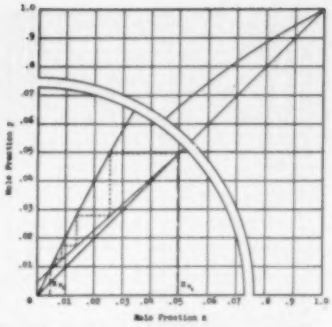

Figure 30. Toluene-Ethyl Benzene System. Fifth Stage—60 Percent Distilled.

If only a few percent of low-boiler is to be removed and a high purity product is not required, the conventional batch still can be used to take the light ends overhead, and when this is done, the rest of the charge can be recovered directly from the kettle in moderate purity. This will save considerable time over completing the distillation batchwise or running the same quantity of material through a comparable continuous still. Such a distillation should not be expected to give a product of high purity.

If, however, a **high degree of purity is required, a batch rectifying still is a very poor tool for the job** since only a poor yield of good product will be obtained per batch if the separation is at all difficult and if a large intermediate fraction has to be recycled the cost advances.

A batch still is a poor tool to use for any distillation involving a component which, at the temperatures in the still, has tendencies to decompose or to polymerize. In a batch still the whole charge is subjected to high temperatures for long periods of time, whereas a continuous still with a low inventory reboiler of proper design permits the distillation at minimum temperature and at minimum time of exposure to the still temperatures. Because the inventory time in a continuous still is so much less than for a batch still, the maximum still temperature allowable when distilling heat sensitive materials may be as much as 20 to 30° C. higher for the continuous still.

2. *Batch Stripping Still*

If a large accumulator is placed below the condenser and the total still charge is placed therein, and this material is slowly fed to the top of the column while product is taken off from

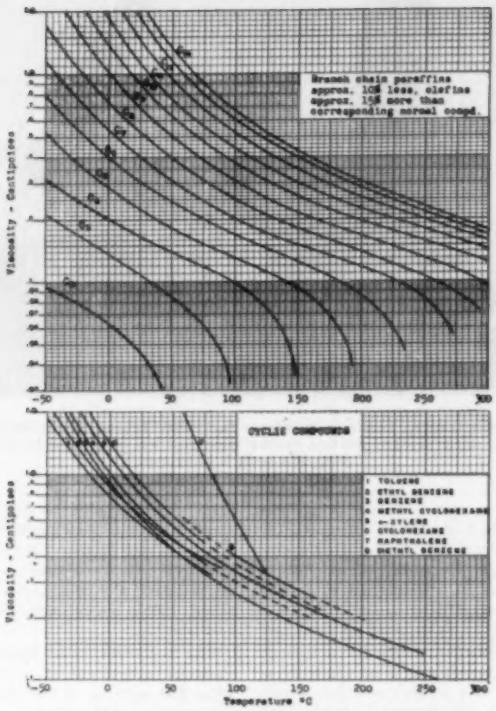

Figure 31. Viscosity-Temperature Relation Normal Paraffins.

the reboiler, one has a batch stripping still sometimes called a "backward" still. This type of still has the same characteristics as a batch rectifying still except in reverse.

This still will do a good job of removing traces of low-boiler from a given component but the distillation must be run to completion to accomplish this.

If only a few percent of high-boiler is to be removed and a high purity product is not required, this type of still can be used to remove most of the high-boiler by running only part of the charge through the still, thus saving considerable time.

The batch stripping still is a very unsatisfactory tool for trying to get a high purity product by removing a high-boiling impurity.

3. *Continuous Rectifying Still*

A continuous rectifying still would be a good tool for removing a small amount of high-boiler from an otherwise pure material. It has the disadvantage that appreciable low-boiler would be carried out with the bottoms. The usual application of this type of still is gas absorption.

4. *Continuous Stripping Still*

A continuous stripping still would be a good tool for removing light ends from a given material. It has the disadvantage that appreciable high-boiler would be carried overhead along with the low-boiler. The most common application of this type of still is its use to remove gas from an absorbent.

5. *Continuous Still*

A continuous still with both a stripping and a rectifying section (feed entered in or near the middle 1/3 of the column) **will in most cases give the most efficient use of a still column.** In this case the purity of both overhead and bottoms is subject to control.

6. *Still Combinations*

For preparing research quantities of pure materials, it is a mistake to rely on batch distillation alone for usually there are at least traces of impurities which boil both above and below the desired component. For such cases a good procedure would be as follows:

> Suppose a given sample contains in addition to the desired component 2.5 percent of low-boiler and 10 percent of some higher boiling impurity. The sample should first be continuously distilled, taking 5 percent or 10 percent overhead. The bottoms will have left in it only the barest traces of low-boiler. The 10 percent high-boilers may be removed from these bottoms by re-running them over the continuous still or they may be effectively removed by a batch rectifying still.

This procedure will give a product of high purity with a good yield from the starting material. Of course the number of plates in the column and the reflux ratio must be chosen for both steps such that the column can make the degree of separation required.

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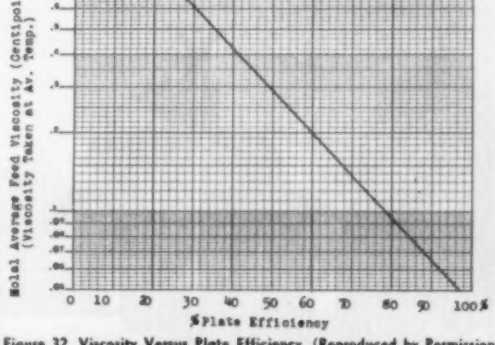

Figure 32. Viscosity Versus Plate Efficiency. (Reproduced by Permission of American Institute of Chemical Engineers.)

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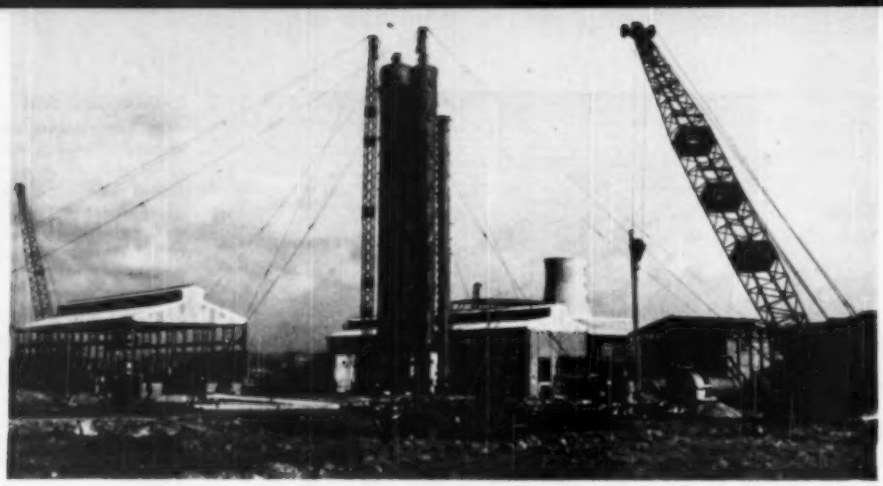


Hoisting a Fractionating Column in Position on Shell's New Refinery Site at Stanlow, England. More than a month ahead of schedule, the first main plant was in operation by early December. Near East crude is being used.

British Teamwork Gives Refinery An Early Start

E. N. TIRATSOO,
London

THE new refinery which is being built by Shell Oil Company at Stanlow near Ellesmore Port, Cheshire started operation early in December, more than a month ahead of schedule. Its first main plant, the distillation unit with associated facilities, has started up the manufacture of gasoline and other petroleum products from Middle East crude oil at the design rate of approximately 7 million barrels per annum (nearly 20,000 barrels daily.)

This achievement has been made possible by an outstanding effort of the 1500 men employed on the construction staff comprising both Shell employes and British contractors.

As an example of the difficulties that have been overcome the accompanying photographs show how one of the new fractionating columns, which is 84 feet long and 10 feet 8 inches in diameter and weighs 115 tons was transported through the heart of England from the makers' work-shops in the suburbs of London to the Shell plant at Stanlow. This was the largest fractionating column ever made in Britain for the home oil industry and was carried on a 32-wheel double bogey hauled by three 20-ton tractors.

The Shell refinery at Stanlow is being extended at present at a cost of more than $50 million. It lies alongside the new Shell chemical plant which was opened in the summer of 1949 and which is expected to prove of considerable significance to British economy.

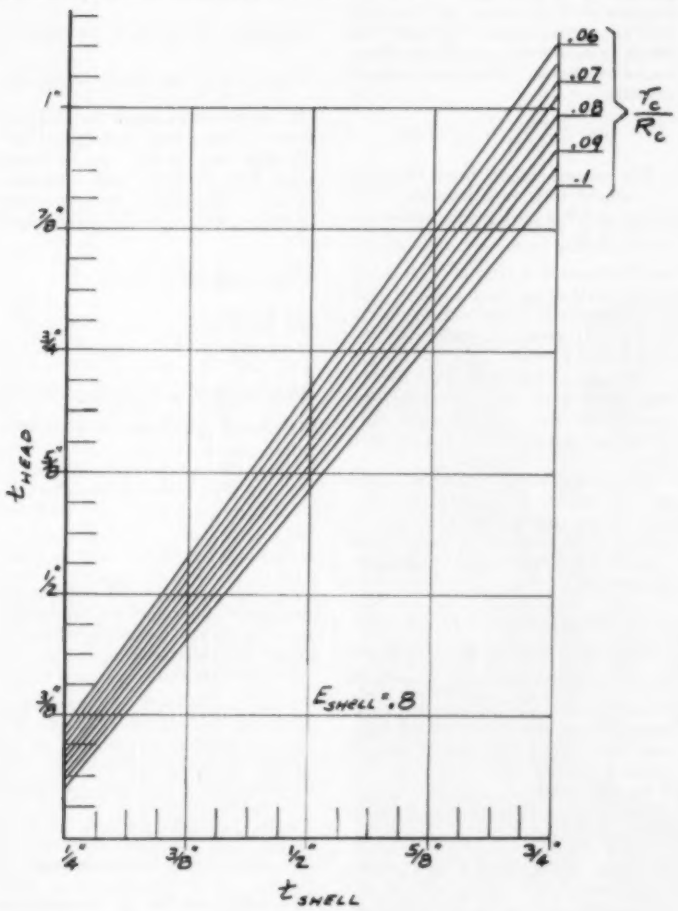
Another refinery is being built at Shell Haven in Essex, and it is estimated that the Stanlow and Shell Haven refineries, which will mainly process sterling crude oil from the Middle East, will have a combined capacity of 42-million barrels per annum (between 110,000 and 120,000 barrels daily) making Shell Oil Company the largest British home producer of petroleum products.

On the 250-mile journey from G. A. Harvey & Company, Ltd. Shops at Woolwich, this 115-ton column is shown at Hyde Park Corner in London heading for the Edgware road. Stanlow is near Liverpool, while the fabricating plant is in East London.

Pressure Vessel Considerations—

Flanged and Dished Heads

HARALD E. LONNGREN
Mechanical Engineer, New York



EQUAL strength of a shell and a dished head is contained in the expression,

$$\frac{2\,S\,E_s\,t_s}{D_m} = \frac{2\,S\,E_h\,t_h}{R_c\,W}$$

Wherein,

S = Allowable stress of the material
E_s and E_h = Efficiency of welded seams
t_s = Shell thickness
t_h = Head thickness
R_c = Mean crown radius
W = A factor per chart in the code
D_m = Mean diameter of the drum.

When there are no seams in the head $E_h = 1$. The mean crown radius R_c is commonly equal to the mean diameter of the drum — D_m — or somewhat smaller, approximately $.9\,D_m$.

Thus,

$$t_h = t_s \times E_s \times W \quad (R_c = D_m)$$

or

$$t_h = t_s \times E_s \times W \times .9 \quad (R_c = .9\,D_m)$$

The factor W again is a function of ratio,

$\frac{r_c}{R_c}$ (See chart in the API-ASME code.)

In which,

r_c = mean knuckle radius.

The mean knuckle radius must be equal to or greater than $.06 \times D_m$ and in no case smaller than $3 \times t_h$.

When using

$$r_c = .06 \times D_m$$

and

$$R_c = D_m$$

the ratio

$$\frac{r_c}{R_c} = .06$$

This is the minimum value permissible for new designs. The factor W = 1.78 for this case.

When

$$r_c = .06 \times D_m$$

and

$$R_c = .9 \times D_m$$

The ratio,

$$\frac{r_c}{R_c} = .066 \text{ and } W = 1.74$$

Thus,

$$t_h = 1.78 \times t_s \times E_s \quad (R_c = D_m)$$

or

$$t_h = 1.566 \times t_s \times E_s \quad (R_c = .9 \times D_m)$$

Thus,

$t_h = 1.424 \times t_s$ When $E_s = .8$
$t_h = 1.513 \times t_s$ When $E_s = .85$
$t_h = 1.602 \times t_s$ When $E_s = .95$ } $\frac{r_c}{R_c} = .06$
$t_h = 1.691 \times t_s$ When $E_s = .95$

Similarly,

$$\left.\begin{array}{ll} t_h = 1.253 \times t_s & \text{When } E_s = .8 \\ t_h = 1.331 \times t_s & \text{When } E_s = .85 \\ t_h = 1.409 \times t_s & \text{When } E_s = .9 \\ t_h = 1.487 \times t_s & \text{When } E_s = .95 \end{array}\right\} \frac{r_c}{R_c} = .066$$

It will thus be readily seen that t_h is a simple function of t_s. The graphical representation is a straight line.

From the general equation,

$$t_h = t_s \times E_s \times W$$

it will be noted that t_h is still a function of W or of the mean head radius.

A designer may choose any ratio of $\frac{r_c}{R_c}$ to suit his conditions as long as he adheres to the stipulation that $\frac{r_c}{R_c}$ must be greater than .06. The maximum limit is when $\frac{r_c}{R_c} = 1$ in which case $W = 1$, or,

$$t_h = t_s \times E_s \text{ (for a seamless head)}$$

Flanged and dished heads—which conform to the requirements of the API-ASME code—have been standardized in order to enable a fabricator to keep a stock of dies required in the forming process. For this reason a designer should strive to use such standard heads as far as possible. Such heads thus come with predetermined crown and knuckle radii, measured along the *inner* contour of the head. A slight deviation from the strict sense of the code has been accepted because it is more practical to form a dished head with a maximum crown radius which is equal to the outside diameter of the drum (not equal to the mean diameter as the code stipulates).

Whether a designer actually chooses to use a ratio of $\frac{r_c}{R_c}$ to his own liking or uses the ratios inherent in a "standard" head, as supplied by a fabricator, depends entirely upon the kind of vessel before him.

For instance, if the vessel is to be installed in a space where cramped conditions exist he automatically decides to use as shallow heads as possible. If however, a balanced design results in too thick heads, which of course is costly, he is obliged to use deeper heads, ultimately perhaps going to the elliptical type altogether if it proves to be the least costly way out.

The most common field of application for flanged and dished heads is represented by vessels which take on a shell thickness equal to $\frac{D + 100}{1000}$ plus up to $\frac{3}{8}$ inch or so of an allowance for corrosion. For vessels of this category, of diameters say up to 8 feet, a designer would most likely decide upon a $\frac{r_c}{R_c}$ ratio ranging from .06 to .1. In all probability he would make his choice within this range also when the ultimate shell thickness (t_s) does not exceed approximately $\frac{3}{4}$ inch — in which case, assuming an 8-foot drum — the maximum allowable internal pressure is,

$$p = \frac{22000 \times .75}{95.25} = 190 \text{ psi.}$$

The corresponding head thickness (t_h) would then vary between 1.069 inches and .924 inch, the first thickness corresponding to a $\frac{r_c}{R_c}$ ratio of .06 and the latter to a ratio of .1. It is not a good practice to attach a dished head to a drum when the differential in thickness is great. A good rule is to keep $t_h < 1.5 \times t_s$.

The longitudinal shell seams of vessels referred to need not be radiographed in their entirety, and very seldom are. Thus, $E_s = .8$ is a common case.

The plotted results apply to drums of sizes which a designer most frequently encounters. Similar charts can readily be worked out for cases which require stress relieving or radiographing or both.

How to Use the Chart

Suppose a designer has reasoned for himself that a ratio of $\frac{r_c}{R_c} = .06$ is the most suitable for his particular case at hand. Say that his shell thickness calculations gave him an over-all value of $t_s = \frac{3}{8}$ inch.

He then reads off the value of t_h at the intersecting point between the ordinate $\frac{3}{8}$ inch and the line $\frac{r_c}{R_c} = .06$. He finds that $t_h = .534$ inch or say 17/32 inch.

The dish radii along the inner contour of the head are then,

$$R = R_c - \frac{t_h}{2} = D_m - 17/64\text{-inch.}$$

$$r = r_c - \frac{t_h}{2} = .06 \times D_m - 17/64\text{-inch.}$$

If, on the other hand, the designer chooses to use a head with "standard" dish-radii—say, in this case, a crown radius R = 36 inches and a knuckle radius r = 2¼ inches, the given chart should be used in the following manner.

First, establish the ratio $\frac{r}{R}$.

In this case:

$$\frac{r}{R} = \frac{2.25}{36} = .0625$$

This value is not identical with the true value of $\frac{r_c}{R_c}$. It will be noted that

$$\frac{r_c}{R_c} = \frac{r + .5\,t_h}{R + .5\,t_h}$$

or that

$$\frac{r}{R} < \frac{r_c}{R_c}$$

Just how great the difference is depends upon the sought for head thickness. The thicker a head becomes, the greater this difference is.

To illustrate this:

$$\frac{r}{R} = .0625 \text{ (Constant up r} \geqq 3t_h)$$

$$\frac{r_c}{R_c} = \frac{2.25 + .188}{36.188} = .0673 \text{ for a } \tfrac{3}{16}\text{-inch thick head}$$

$$= \frac{2.25 + .375}{36.375} = .072 \text{ for a } \tfrac{3}{4}\text{-inch thick head.}$$

To simply use the $\frac{r}{R}$ value directly

FLANGED AND dished heads are commonly attached to a drum by means of butt-welding. Because of their shape such heads require a greater thickness than the thickness of the shell onto which they are attached.

No doubt deigners have experienced difficulty in the use of the API-ASME code formula for dished heads because it is actually impossible to determine the true value of the mean radii without knowing the head thickness itself. The code formula for t (the thickness) contains the factors W and R_c which in turn are functions of the sought for thickness.

For a balanced design—shell and heads of equal strength—there is a definite relationship between the shell and head thicknesses. This is so because the mean head-radii can readily be expressed in terms of the mean diameter of the drum.

The author has worked out a typical graph showing the relationship between the required head thickness and the readily established shell thickness.

This graph, together with Mr. Lonngren's underlying derivations and design considerations will, no doubt, prove to be a useful tool for designers of pressure vessel parts.

as such in establishing the head thickness will thus not result in a closely balanced design. The head will, as a result, be the stronger.

With the aid of the chart, however, a designer will have a clear picture before him of how to arrive at a balanced design.

An actual case would be the following. For instance,

$$\frac{r}{R} = \frac{2.25}{36} = .0625 \text{ (36-inch o.d. head)}$$

$$t_s = 3/8"$$

Using the $\frac{r}{R}$ value as a guide, it will be found from the chart that the head thickness is very close to .515 inch.

Thus, a fairly true value of $\frac{r_c}{R_c}$ is,

$$\frac{r_c}{R_c} = \frac{2.25 + .258}{36.258} = .07$$

Checking this result the ordinary way we have

$$P_{shell} = \frac{22000 \times .375}{35.625} = 231 \text{ psi.}$$

$$P_{head} = \frac{27500 \times .515}{36.258 \times 1.69} = 232 \text{ psi.}$$

Conclusions

For most practical purposes the API-ASME formula as such gives answers which result in a fairly well balanced design. Plate thicknesses are usually rounded off to the nearest sixteenth of an inch. Thicker plates for larger vessels are specified in thirty-seconds of an inch, so as to effect a substantial saving.

It will be seen from the given chart that the actual variation in the required head plate thickness, within the given range of the $\frac{r_c}{R_c}$ ratio, is rather small.

For a 3/8-inch thick shell plate for instance,

$$\left.\begin{array}{l} .534 - .462 = .072 \\ \text{and for a } 3/8" \text{ thick shell again,} \\ .89 - .77 = .12" \end{array}\right\} E_s = .8$$

When a designer realizes before hand that the head plate thickness will actually be thicker than the shell plate at hand, he may readily use this knowledge to advantage when "trying" to obtain a fair estimate of the $\frac{r_c}{R_c}$ ratio.

Thus, in the aforementioned example (butt-welded head, $E_s = .8$) he knows that,

$$\frac{r_c}{R_c} = \frac{2.25 + .2}{36.2} = .076 \text{ (practically)}$$

From the chart, he will then read off a head plate thickness of .5 inch which corresponds to a pressure of

$$P_{head} = \frac{27500 \times .5}{36.25 \times 1.65} = 230 \text{ psi.}$$

He would thus specify a minimum head plate thickness of 1/2 inch at the knuckle which is close enough for practical work.

The author knows of no previous disclosure of a graphical illustration of the type given herein, which shows plainly the true relationship between the shell thickness and the required head plate thickness for flanged and dished heads which are attached to a drum by means of butt-welding so as to obtain equal strength of the shell and the head.

It is hoped that this work will prove to be useful in design and drafting rooms where pressure vessels are being born, aside from being a humble contribution to the engineering knowledge in general.

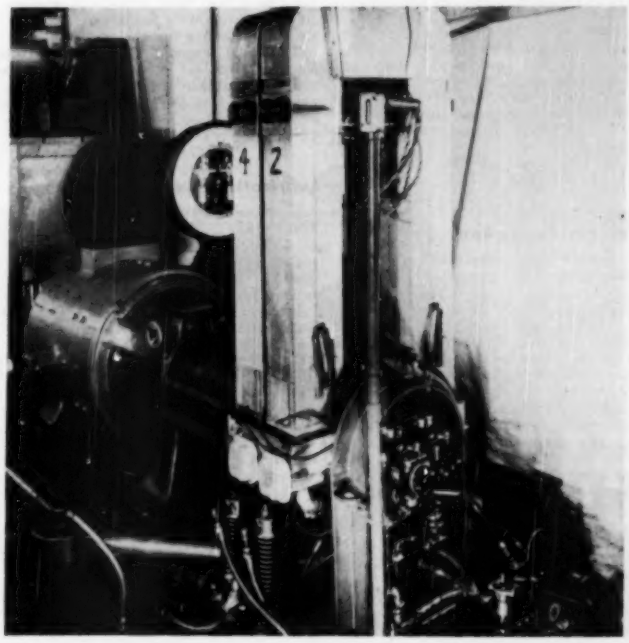
* * *

Test Evaluates Aircraft Engine Oils

A NEW test for evaluating aircraft engine oils has been developed in the Beacon Laboratories of The Texas Company. Using a four-cylinder air-cooled Continental aircraft engine, Texaco engineers have installed a unique temperature control system which permits a simultaneous check of oil performance under different temperatures. Note picture at right.

Each cylinder is operated at a different temperature, and four thermocouples are attached to each. Temperatures from the thermocouples are averaged and fed into an automatic indicator. Motor-controlled dampers are used to maintain the cylinder at the desired temperature levels.

Since engine cleanliness is closely tied up with temperature problems, this test permits the engineer to determine oil performance under a wide temperature range on a single run. It also permits tests for bearing performance. The engine is attached to a dynamometer absorbing the full-load horsepower output that would normally be transmitted to the aircraft propellor.



BOOKS of Current Interest

Refinery Safety Manual

"Safety in the Petroleum Refining and Related Industries," a comprehensive manual of refinery safety information comprises approximately 425 pages containing 238 photographs, charts, flow diagrams and other illustrations. The book was prepared for John G. Simmonds & Company, Inc., insurance firm, by George Armistead, Jr., consulting chemical engineer of Washington, D. C. The author has long been associated with refinery safety work and prepared one of the first widely distributed safety inspection manuals for Gasoline Products Company, Inc., in 1938.

Included in chapter discussions are principles of safety; fundamentals; plant layout; the fire protection of structures; mechanical standards for construction and maintenance; operating practices affecting safety; relief and blowdown systems for process units; storage tanks; maintenance practices affecting safety; static electricity and other ignition sources; outline of inspection practices; fire control and extinguishment. Eight appendices give properties of flammable gases, liquids and solids; a table of common hazardous chemicals; guide to the corrosion resistant properties of construction materials; specifications for reinforced concrete fire protective in sulation; specifications for brick fire protective insulation; inspection tools, devices and equipment; retiring thicknesses for tubes in fired heaters, and retiring thicknesses for piping.

Tabulations in the appendix show detailed properties of 323 flammable liquids, vapors and solids, and of 115 common hazardous chemicals. Another tabulation gives allowable operating pressures for various sizes of piping and heater tubes under a wide range of temperatures and thickness.

George Armistead, Jr., 1200 18th Street, Washington 6, D. C., price $10.

Petroleum Compounds

As a part of a cooperative research program designed to increase the utilization of high-sulfur crude oils the Bureau of Mines has issued a new report in a series listing data on the physical properties of sulfur compounds most likely to be found in petroleum and its products. Based on work dong in cooperation with the University of Wyoming at the bureau's petroleum and oil-shale experiment station at Laramie, Wyo., the report identifies the most common sulfur compounds and provides information useful in devising methods for removing these objectionable impurities. It was prepared by R. Vernon Helm and William E. Haines, petroleum chemists, and John S. Ball, refinery engineer at the experiment station.

Revised and additional data taken from Chemical Abstracts for 1946 and 1947 on boiling points, refractive indices, densities, and freezing points are included in the report. In addition, tables show refractive indices for wave lengths of light other than the sodium D line, surface tensions, viscosities, and values for derived functions, such as refractivity intercepts, specific dispersions, specific refractions, and parachors. A suggested nomenclature of sulfur compounds also is discussed.

Report of Investigations 4566, Sulfur in Petroleum: III. Selected Physical Properties of Some Sulfur Compounds, Bureau of Mines, 4800 Forbes Street, Pittsburgh 13. Free.

Rocky Mountain "Black Oils"

For commercial use, the asphalts produced from Rocky Mountain "black oils" compare favorably with those obtained from other crude oils widely used by the asphalt industry, according to a technical report prepared by the Bureau of Mines. Results of studies made by the bureau's petroleum and oil-shale experiment station at Laramie, Wyo., in cooperation with the University of Wyoming are given. The report was prepared by R. E. Stanfield and Rethel L. Hubbard, chemists at the experiment station. Studies of 117 asphalts from 25 crude oils of Wyoming, Montana, Arkansas, California and Mexico are covered in the report. The information points up the suitability of Wyoming asphalts for commercial applications, but their suitability for specific uses was not determined by service and performance tests.

Technical Paper 717, Asphalts from Rocky Mountain Crude Oils, Laboratory Preparation and Comparison, Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 25 cents.

Lubricating Turbine Gears

Symposium on lubrication of high-speed turbine gear equipment, presented at a 1949 Washington meeting of technical committee C of the American Society for Testing Materials Committee D-2 on petroleum products and lubricants, is available in **Technical Publication No. 92.** Included are papers on "Lubrication of Naval Gearing"; "Developments in Gear Design and Their Lubrication Requirements"; "Physical Concepts of the Establishment of the Lubrication Oil Wedge and Its Associated Load Carrying Capacity for the Mating Tooth Surfaces of High-Speed Gears"; and "Fundamentals of Worm Gear Lubrication".

Pictured are operating and design problems as well as what has been accomplished in perfecting gears and lubricating systems to bring about improvements in geared sets and the possible improvements yet to be realized.

American Society for Testing Materials, 1916 Race Street, Philadelphia 3. 75 cents.

Pump Standards

Hydraulic Institute's new book on standard classification of pumps is divided into four general classes with a section devoted to each class. Each class is subdivided into types, differing in the design of the details, but having features that are common to that type.

This eighth edition of **Pump Standards,** prepared through the cooperation of Institute Members, some non-member pump manufacturers, ASME, and others, contains what is considered good engineering practice and it is expected that the standards will be of mutual advantage to the purchasers and users of pumps, and the engineering profession, as well as to the pump manufacturers. The Institute is hopeful that these recommendations will be considered as standard trade definitions and customs.

In the section devoted to centrifugal pumps, centrifugal (single and multistage), propellor, mixed flow, and peripheral types are described. Materials of construction; nomenclature; standards of volume, head, power, and efficiency guarantees; calculations for specific speed, suction lift, and suction head; installation instructions; operating instructions, and special applications are discussed. Also included is the test code for centrifugal pumps.

In the section on rotary pumps, full information is included on cam, screw, gear, and vane types similar in extent to the centrifugal pump section. Sections on the reciprocating and deep well pumps are fully as complete.

Pump Standards, Hydraulic Institute, 90 West Street, New York 6, $3.00.

Petroleum Testing Methods

Apparatus for and the procedure of 116 methods for determining physical and chemical properties of crude petroleum and its products are described in the tenth edition of **Standard Methods for Testing Petroleum and Its Products,** a 660-page book published by the Institute of Petroleum, London. Three new methods are 1) an engine method of testing heavy-duty lubricants in relation to ring-sticking, wear, and deposit accumulation; 2) a method for research octane number of motor fuels, and 3) a method of assessing the corrosive tendencies of cutting oils in contact with cast iron. Various methods have been revised in detail, including calorific value (now known as heat of combustion), distillation, and viscosity.

Institute of Petroleum, 26 Portland Place, London W. I. 31s.6d. Price (about $4.41).

Lathe Operators' Handbook

"How to Run A Lathe", a revised book of South Bend Lathe Works, contains data and more than 350 illustrations on the care and operation of metal-working lathes. This book is said to be useful as a reference by experienced machinists or as a text by the apprentice or shop student. Eleven chapters cover various types of work including the correct installation and leveling of the lathe, grinding cutter bits, turning, boring, thread cutting, taper turning, drilling, reaming, and tapping.

South Bend Lathe Works, South Bend 22, Ind., paper binding, 25 cents; fabricoid binding, $1.00.

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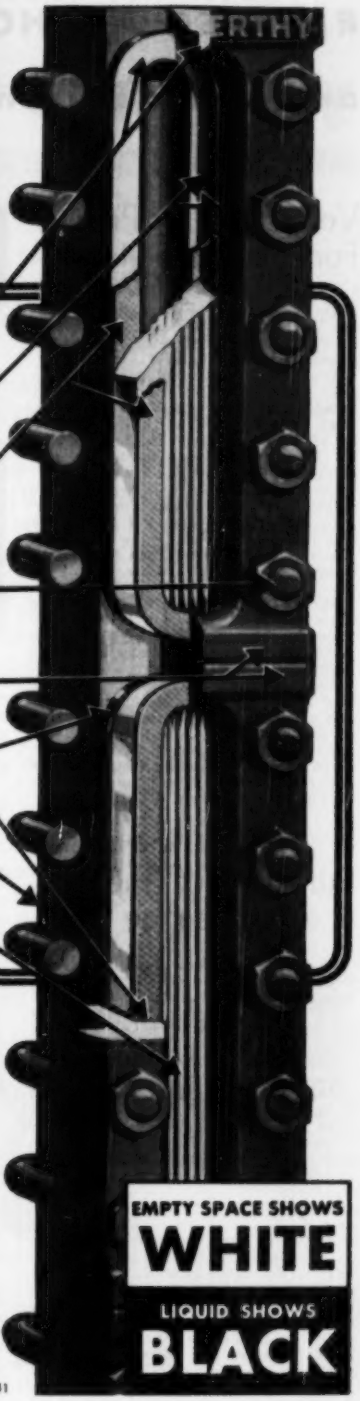

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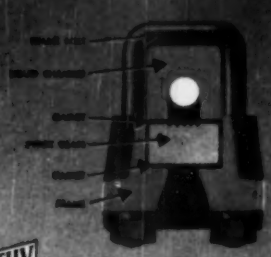

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REFINER AUTHORS and Other Personalities

Information, formal and otherwise, about the men who write for PETROLEUM REFINER as well as others prominent in the industry.

Vermonter on Pumps For Viscous Materials

William E. Worcester, whose article begins on page 115 of this issue, "Pumping Viscous Materials," is vice president in charge of foreign sales for Kinney Manufacturing Company, Thetford, Vt.

Worcester was born in Thetford in 1887. He was graduated from Thetford Academy (1904), Ann Arbor, Mich., High School (1905), and the University of Michigan (1910) A.B. At Michigan he majored in history, economics, and completed a third of the law course.

On March 1, 1910, he entered the employ of Kinney Manufacturing Company. During his first six months he was in charge of tests, plus some purchasing and shipping. Then he was assigned to the sales department and for two years sold through the Mid-West.

Worcester opened the Philadelphia branch of the company in 1912, and remained as branch manager until 1932, when he was appointed to his present position.

He is married and has four children. His favorite hobbies are fishing, golfing, and gardening. He has been a member of the Engineers Club of Philadelphia and the American Society of Mechanical Engineers and presently is active in the University Club of Boston and a trustee of Thetford Academy.

W. E. WORCESTER L. E. LLOYD H. N. (JACK) FROST

Pure's Chief Chemist Is a Big League Fan

H. N. (Jack) Frost is almost sure that he gave up a career in major league baseball for that of a chemical engineer. Jack, popular member of the Smiths Bluff refinery of The Pure Oil Company, Nederland, Texas, holds the official title of chief chemist. He is the author of PR's three-part series on naphthas. Part I, "Aliphatic Petroleum Naphthas in Industry," begins on page 95 in this issue. Part II, "The Assay of Stocks for Aliphatic Naphtha Production" will appear in March, and "The Manufacture of Aliphatic Petroleum Naphthas," in April.

Back in 1925, when he was a freshman at Texas Christian University in Fort Worth, Jack found he had to make a choice between baseball and chemical engineering. The engineering career won by a slight margin, and Jack moved down to Austin to attend the University of Texas. He was graduated in 1929. After graduation he went to work as chief chemist for Champlin Refining Company in Enid, Oklahoma. From 1930 to 1933 he was plant engineer for Texas Pacific Coal and Oil Company back in Fort Forth. It was about that time he joined The Pure Oil Company.

Jack is quite a baseball fan, so much so that his idea of celebrating the solution of a tough problem is to attend all the local Texas League games. His one complaint in the matter—not enough refineries are built in the major league cities. He is a home movie and amateur radio fan, and says he will go into action to show his movies at the slightest provocation. The advantage in being a native Texan, he proudly relates, is that even in Texas you can tell tall tales without somebody "calling your hand"—and only in very rare cases proving it.

Figure Skater Gives On Batch Distillation

L. E. Lloyd has not only equipped himself fully with the facts and figures of batch distillation, but reports that his figure skating figures are well in hand. Lloyd's article, "Batch Distillation, Characteristics and Limitations of a Batch Still," begins on page 135 in this issue of PR.

The Lloyds are both figure skating teachers and four-year old daughter, Vonnie, is already accomplished along the same line. As a matter of fact, the family is referred to as "the skating Lloyds," which is not too surprising when a family likes to be outdoors in Michigan. Lloyd also spends much of his free time canoeing and woodworking.

Lloyd was born in Clyde, N. D., in 1907. He attended Manchester College for a degree in chemistry in 1931, and received his Sc.D. degree in physical chemistry from the University of Michigan in 1937.

He joined The Dow Chemical Company in 1937 and until 1942 did research and development work in the laboratory on ethylene purification and by-product recovery and utilization. This work led into studies on production and fabrication of vinyl type plastics. In 1939-42, he was section head in charge of a distillation unit which did hundreds of laboratory and small pilot-plant distillations each month.

From 1942 to 1943, he was a member of an engineering team charged with the design responsibility for the Rubber Reserve styrene plants built by Dow. He returned to the laboratory in 1944 and did research and development work on new vinyl type monomers for plastics. He became a staff member in the plastics manager's office in 1945.

Lloyd reports that his real interest in comparisons between batch and continuous stills began in 1944. In taking an engineering approach to research on separation processes for new monomers, he found it necessary to make large enough samples of pure compounds and isomers to get the physical data required for engineering calculations. Experience with even the best of batch stills proved very disappointing. In trying to find out why, he decided that he was expecting too much from the batch still. His article is a summary of his studies and conclusions.

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ABOUT TUBE CLEANERS

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Why do the men on the firing line in a tough job of still tube cleaning, almost invariably demand Lagonda where they have any choice? It is because the Lagonda has the power and stamina to tear through the job quickly, to make a mean task easier, to complete its assignment without failure or undue trouble.

According to one refinery engineer, the only thing his men worry about is that "the exceptional power of the motor will tear up the cutter head." This has never happened. And it will not, either, if it's a Lagonda cutter head — for while the 1100 series Lagonda cleaner, with its ball thrust bearings and full lubrication system, transmits all the power of compressed air with practically no friction loss, the Lagonda cutter head of any type is built to take it, developed through long experience to balance the power of the motor behind it.

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Rugh, Mattocks Give Annual Data on LPG

The annual LPG report by K. W. Rugh and E. O. Mattocks, Phillips Petroleum Company, appears in the economic section of PR this month. The article, "LP-Gas Sales Continue to Gain in 1949" begins on page 133. Rugh and Mattocks have been releasing these reports to the industry for the past several years and are widely recognized as authorities on LPG marketing.

K. W. Rugh manager of the Philgas division of the sales department of Phillips was born in Greeley, Colo. After attending the University of Illinois, graduating in commerce and business administration, he joined Phillips in 1930 and has been engaged in marketing continuously since that time. He has been active in the Liquefied Petroleum Gas Association since its organization. A member of its board of directors, he also has been chairman of the legislative committee for several years.

The Rughs have two children, a boy and a girl. Rugh's hobby is a natural one for a native of Colorado—hunting.

E. O. Mattocks, better known to his friends and associates as just plain Elmer, is the technical representative of the chemical engineering department of Phillips. He is widely known throughout the natural gasoline-LPG industry. Born in Elmira, N. Y., Mattocks, is a graduate of Cornell University in mechanical engineering. Also, he is a member of Phi Kappa Phi fraternity.

Mattocks worked five years for the Syracuse Lighting Company, Syracuse, N. Y., (now Central New York Power Corporation), six years with the American Gas Association Testing Laboratories in Cleveland, Ohio, and then joined Phillips as industrial engineer. He is active on various committees of the AGA, API, American Society for Mechanical Engineers, American Society for Testing Materials, Compressed Gas Manufacturers Association, Liquefied Petroleum Gas Association, National Fire Protection Association, and Natural Gasoline Association of America.

The Mattocks have three daughters, ages 5, 15, and 20.

Pipe Bending Moments Now Blick's Subject

Robert G. Blick contributes his second article to PR with the three-part series beginning on page 101, "Bending Moments and Leakage at Flanged Joints." His first presentation, "Pipe Supports and Pipe Restraints" appeared in the December, 1949, REFINER.

Blick is a member of the stress analysis division of Lockheed Aircraft Corporation of California. He was an engineer with The M. W. Kellogg Company from 1942 to 1946, except for a period as radio-theory instructor in military service. He then joined Project Engineering Company as head of the piping stresses group.

When he is not refinishing old furniture, one of his hobbies, Blick indulges in another—designing radio apparatus. He has designed several pieces of Signal Corps equipment and is writing a paper on a new type of feedback amplifier.

The Blicks have three small daughters. It now appears that the Blicks, who met while both were studying at Cooper Union, will be adding two additional hobbies—fishing and kite flying, according to the two older daughters.

E. O. MATTOCKS K. W. RUGH HEINZ HEINEMANN

Patent Author Writes Sugar Cane Feature

Dr. Heinz Heinemann, author of PR's monthly "Digest of Recently Issued U. S. Patents Pertaining to Petroleum Refining," joins the list of contributing authors in this issue with the article beginning on page 111, "Petroleum Type Hydrocarbons from Sugar Cane."

Dr. Heinemann is project director for Houdry Process Corporation and is active in research and petroleum refining, particularly in the application of adsorbents and catalysts. His research has been chiefly in the field of catalytic refining. Previous to joining Houdry, he was research chemist and research supervisor with Attapulgus Clay Company, Camden, N. J.

A graduate from the University of Berlin and Technische Hochschule, Dr. Heinemann received his doctorate at the University of Basle, Switzerland, in 1937. He worked on synthetic fuels at the Franks Laboratories in Berlin for a year before coming to the United States. For several years, he was chief research chemist for Rodessa Oil and Refining Corporation, then in 1940, he joined Danciger Oil and Refining, Inc., and 1941 became a research-fellow at Carnegie Institute of Technology, serving as assistant to the late Dr. Ernst Berl. During his work on the fellowship, Dr. Heinemann organized the research fellowship of the Dominican Republic.

Dr. Heinemann is author of several technological papers, a member of the American Chemical Society, New York Academy of Sciences, American Society for X-Ray and Electron Diffraction, Schweizerische Chem. Gesellschaft and A.A.A.S. He is an abstractor for Chemical Abstracts, also.

Chief interests of Dr. Heinemann is research in catalysis and hydrocarbon technology; organization and administration of research and technical service; literature and patent work, and plant coordination work. He holds ten U. S. patents on this work.

Penn Grade Picks New Man for Pacific Coast

Charles R. Wheeler, Glendale, Calif., has been appointed Pacific Coast field service representative for the Pennsylvania Grade Crude Oil Association. He succeeds E. H. Fallin, who has resigned to join the National Petroleum Association in Washington, D. C.

Wheeler, who for several years has been with the Veterans Administration, was previously Penn Grade representative in the Midwest, with headquarters in Chicago.

Bill Boyd Day Honors Retired API President

Hometown honors were paid William Rufus Boyd, Jr., last month on "Bill Boyd Day" sponsored by the citizens council in appreciation of his service with the American Petroleum Institute. Boyd has returned to his hometown, Teague, Texas, upon retirement as head of the institute.

Among guests paying tribute to Boyd were Tom Connally, senior senator from Texas; W. Alton Jones, president, Cities Service Oil Company and chairman of the API board of directors; Hines H. Baker, president, Humble Oil & Refining Company; Olin Culberson, Texas Railroad Commission member; and G. C. Morris, acting lieutenant governor of Texas.

THESE ARE McKEE SERVICES TO THE PETROLEUM PROCESSING INDUSTRY

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McKee designs complete refineries, individual units for all processes and auxiliary facilities including steam and power plants.

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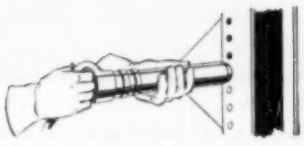
McKee buys all material and equipment, expedites procurement, makes necessary inspection and schedules arrival on the job at the proper time.



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The Chapman Valve Manufacturing Company
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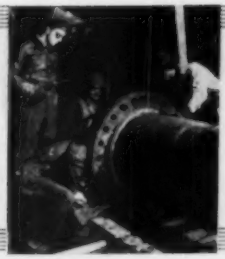
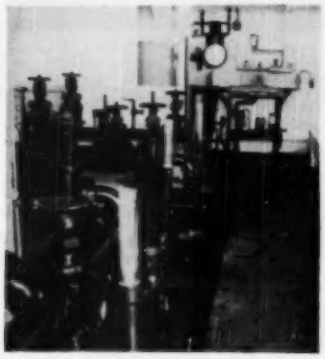


HOW TO DO IT

HOW TO— Install Stainless Steel Hydrometer Graduates

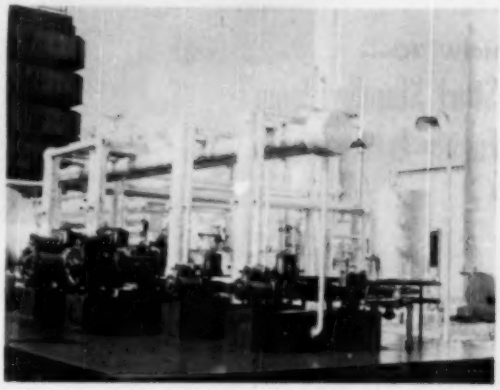
WHEN transferring products where frequent checks on gravity of the materials are necessary, it has been found convenient to install metal cylinders at the discharge of transfer pumps in permanent positions to take the place of



conventional glass graduates. The cylinders are made of thin stainless sheet metal, comparable in size to the ordinary 500 cc. graduate. They are installed, as shown in the accompanying photograph, on two-inch pipe nipples, which contain fittings and connections for attaching to brackets on the pumps and for the piping through which the samples are obtained. Needle valves permit the fluid to flow into the cylinder for the gravity check, then out to the drain. Rubber rings at the junction of the graduate and the two-inch pipe provide a cushion for the bulb of the hydrometer to prevent damage. Each hydrometer cylinder contains a hydrometer, so that checking gravities of a number of streams can be done easily and quickly.

HOW TO— Provide Needed Pipe Support

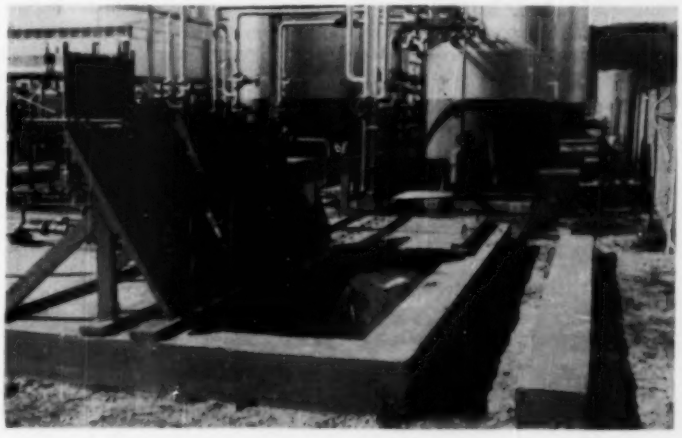
USUAL practice in the design of process area piping in refineries involves overhead lines carried upon support frames of steel or reinforced concrete, and the provision of sufficient flexibility in the terminal lines connecting to process equipment to allow for thermal expansion without overstress of the piping material. On occasion this arrangement can be altered to good advantage. The illustration shows a layout adopted for a group of refinery steam pumps. Supply and return lines at the steam ends of these pumps are short and reasonably stiff. They provide most of the support needed for the overhead steam headers, and are assisted by a light pipe column attached to bolts in the pump foundation blocks.

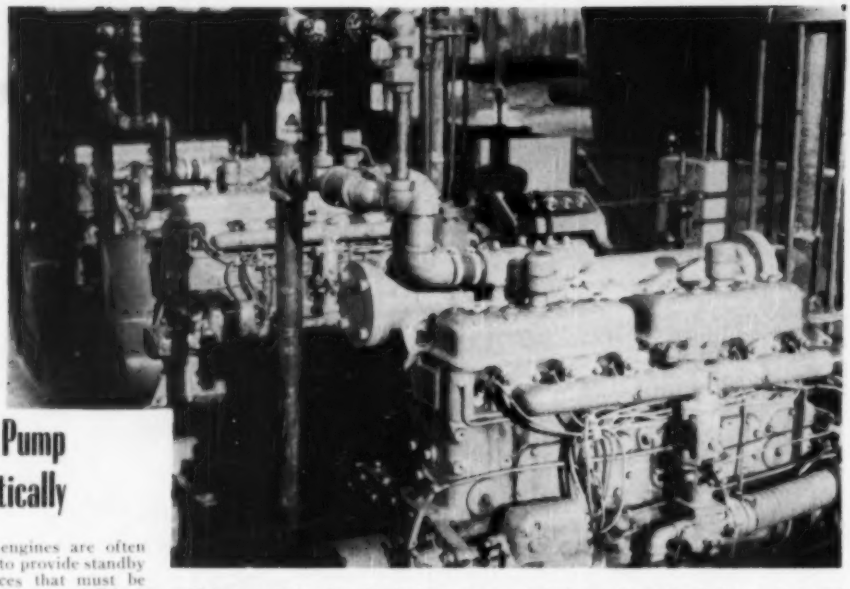


HOW TO— Build Salt Storage For Water Softener

TO ELIMINATE the second handling of rock salt, used in a saline solution tank for the water treating units in a refinery, the solution tank was constructed of concrete below ground level. Dump trucks can unload any quantity of rock salt directly into the tank. The tank is constructed with adequate fluid capacity to back-wash and service the softening units, and to contain a large reserve supply of salt not in solution. The cover of the tank is approximately eight inches above the surface of the ground. Hinged trapdoors attached to the cover are opened from the front wall, so the trucks can unload.

A back-stop, consisting of a substantial rail of concrete is placed the required distance from the tank walls, so the rear wheels of the truck cannot pass farther than the necessary distance to spill the salt over the spreader apron into the tank. This method eliminates building a salt storage warehouse and also provides for bulk delivery instead of sacking, such as employed in some more conventional systems.





Pump room equipped with four multicylinder gas engines operating centrifugal pumps. Nearest engine unit is in continuous operation pumping jacket-cooling water. Standby engine (next engine) is equipped with automatic starting device.

HOW TO—

Start Standby Pump Engine Automatically

GAS and gasoline engines are often used in process plants to provide standby power for vital services that must be maintained during emergency conditions when other sources of power fail. Also, such engines are sometimes used as drivers in normal plant operations.

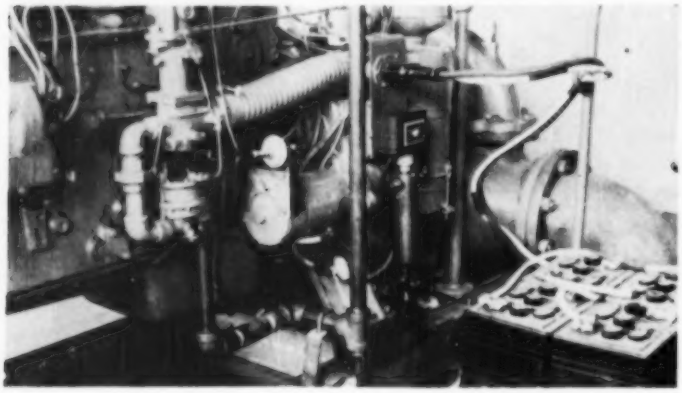
Whatever the service or reasons, standby engines must be started surely and quickly if they are to fulfill their purpose of providing emergency power. Preferably, they should start automatically when needed. Since the starting procedure for internal combustion engines is more complex than for steam or electric drives, providing for the automatic assumption of a load by these engines requires somewhat elaborate control apparatus.

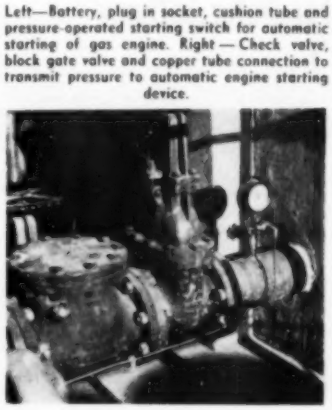
A system used in a California gasoline plant is shown in the illustrations. In this plant four gas-engine-driven centrifugal pumps are used to handle raw cooling tower water and compressor jacket water. The pumps are installed in pairs for the two services. The two pumps in cooling tower water circulation service have sufficient individual capacity so that failure of one unit will not cause an immediate temperature rise to dangerous levels. A single pump provides sufficient capacity for the jacket water circulation system, so the second pump of this pair serves as a full spare. Failure of the single operating jacket water pump results in a prompt and serious temperature rise of the compressor engine jacket water. Therefore the spare pump engine is provided with automatic starting equipment. This apparatus is arranged so that the spare pump will be brought into service when the jacket water discharge pressure drops to about 20 psig.

A spring-loaded starting switch is connected to the discharge side of the pump downstream from a check valve by copper tubing. An oil-filled surge pot below the switch box, cushions the switch against sudden pressure surges in the water line.

To assure starting of the cold gas engine after a few revolutions, a vacuum controller is used to operate the choke butterfly valve in the air intake line to the carburetor. This controller is similar to that used on automobile ignition units to vary the spark timing according to the vacuum in the intake manifold. The controller is mounted on a bracket attached to the end of the starter and connected through an arrangement of levers to the butterfly valve. Full movement of the valve is obtained, from fully opened—when the vacuum is built up in the air intake manifold with the engine running, to fully closed when the engine is idle.

While the regular pump is operating at capacity and maintaining a constant discharge pressure of about 40 psig., sufficient pressure is transmitted to the starting button to overcome the resistance of the spring-loaded starting switch. However, when the pressure drops from 40 to 20 psig., the spring loaded switch overcomes the low pressure and closes the switch to start the engine. After the engine starts and picks up speed, and the pressure on the pump discharge rises above 20 psig., the spring loaded switch is opened, which disconnects the starting motor. As quickly as sufficient vacuum is built up in the intake manifold of the motor, the automatic choke is opened by the vacuum controller and the engine is in normal operation.

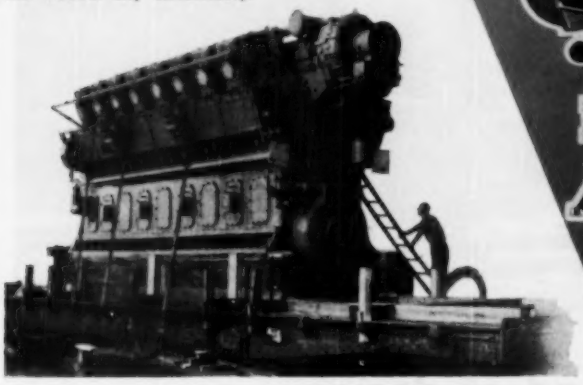




Left—Battery, plug in socket, cushion tube and pressure-operated starting switch for automatic starting of gas engine. Right—Check valve, block gate valve and copper tube connection to transmit pressure to automatic engine starting device.

RIGHT: cross-section of Cooper-Bessemer LSV diesel (15½" bore, 22" stroke) showing rugged, compact design and articulated connecting rods. Features include, large 13½" diameter counterbalanced crankshaft, unusually low bearing pressures, and exceptionally low head room.

BELOW: Cooper-Bessemer 16-cylinder LSV engine, rated 3,400 hp at 327 rpm, mounted on flat car ready for shipment. As shown, complete factory-tested engine can be shipped as a unit without any disassembly.



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featuring . .

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- Compact 12 and 16 cylinder sizes
- Up to 3,400 horsepower
- Full diesel, gas, gas-diesel operation, supercharged or atmospheric

IT is well known that users of Cooper-Bessemer *in-line* LS engines have profited by engine performance seldom equalled in the 800 to 1700 hp class.

Now, the LS "V" design offers *double* the power in *practically the same space*, while retaining the exceptional stamina, high efficiency and low maintenance characteristic of LS operation. *Today, no comparable engine offers as favorable a power-to-space ratio.*

The advantages are obvious. Total power requirements can be met with fewer or smaller engines, permitting big direct savings in the cost of buildings, foundations, installation, over-all operation and maintenance.

Like the in-line LS, the LSV is built as a full diesel, gas-diesel or spark-ignited gas engine. If your interest lies in full or partial gas operation, bear in mind that Cooper-Bessemer gas-diesels offer exceptional efficiency over the *entire* load range. . . and that Cooper-Bessemer spark-ignited gas engines can now be supercharged, permitting sensational new economies compared with ordinary gas engines.

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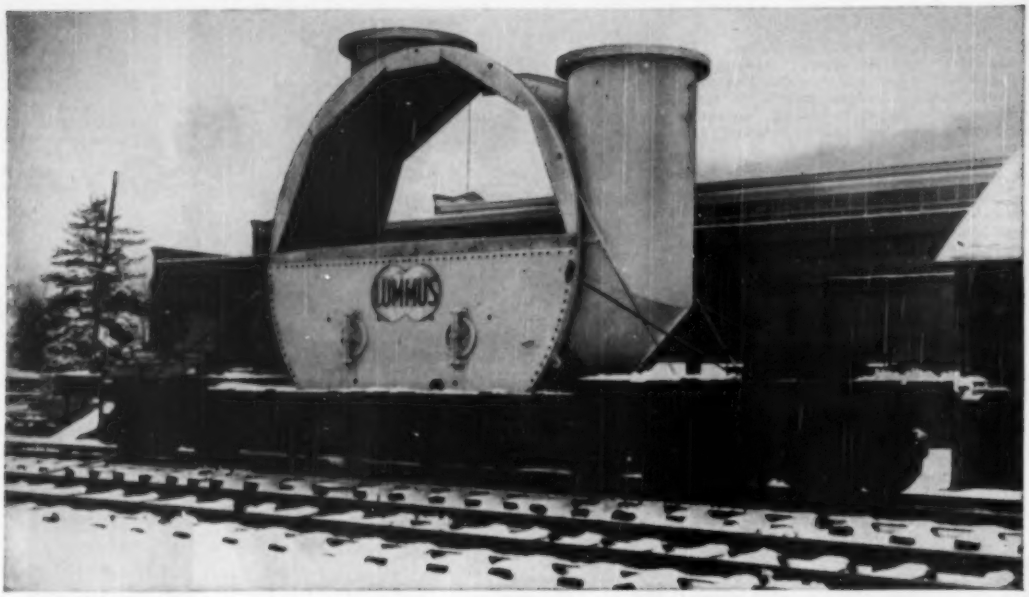

A carload of design and fabrication know-how

Shown above is a 172"-diameter inlet-outlet water box with 54"-diameter flanged connections for a 52,500-sq.-ft. surface condenser. Inaccuracies in the water box cover connections, water-box-to-shell joint, or nozzle alignment could cause trouble and costly delay in installation. Stresses set up by distortions in connection could cause maintenance troubles later.

None of these troubles will happen.

The unit is of all-welded steel construction.

The Lummus design was faithfully adhered to by top-grade welding and machining skill at Lummus' Honesdale (Pa.) plant, where the complete surface condenser was fabricated.

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The MONTH... in the INDUSTRY

Western Refiners Speaking For Two Texas Meetings

Six refinery experts—two from member refineries and four representing engineering and processing companies—are slated as speakers for the Western Petroleum Refiners Association's meeting to be held in Shreveport, La., February 24. This is the first of the 1950 series of regional technical meetings. Included are Harold Bottomly, vice president, Refinery Engineering Company, Tulsa, and Davis Read, Universal Oil Products Company, Chicago. More than 50 refiners are expected for the meeting which is open to the public.

Scheduled to speak at the association's San Antonio meeting, March 27-29 are John S. Bugas, Ford Motor Company vice president in charge of industrial relations, Walter S. Hallanan, newly re-elected chairman of the National Petroleum Council, Henry J. Taylor, American Broadcasting Company news commentator, and John L. McCaffrey, president of International Harvester.

NGAA Convention Slated In April at Fort Worth

John F. Lynch, president La Gloria Corporation, Corpus Christi, has been named program chairman for the 29th annual convention of the Natural Gasoline Association of America, scheduled for April 24-26 in Fort Worth.

Other committeemen are Z. C. Ambrose, Southwest Gas Producing Company, Monroe, La.; W. L. Bowser, The Atlantic Refining Company, Dallas; Otha H. Grimes, Grimes Gasoline Company, Tulsa; F. M. Matheny, Sid Richardson Gasoline Company, Fort Worth; Ralph Worley, Parade Company, Shreveport and W. H. Vaughan, Tide Water Associated Oil Company, Houston.

Authoritative discussions of markets and promotion for liquefied petroleum gases are scheduled for the meeting.

The Natural Gasoline Supply Men's Association will again be in charge of the NGAA convention entertainment.

API-ASME Group Adopts Code Interpretations

The API-ASME committee on unfired pressure vessels has adopted a series of interpretations of the API-ASME code for the design, construction, inspection and repair of unfired pressure vessels for petroleum liquids and gases. The announcement, made by W. T. Gunn, director of the API division of refining and secretary to the committee, explained that pending the formulation and adoption of a section of the API-ASME code to provide additional rules for the used of high alloy steels, as well as for the use of the high strength steels, the approved ASME cases are listed by number and descriptive title. In applying these cases, the API-ASME rules for design and inspection may be followed. The rules governing fabrication shall be those given in the ASME code except as modified.

Detailed information can be obtained through the API Department of Information, 50 West 50th St., New York 20.

Hallanan Re-Elected

Walter S. Hallanan, president of Plymouth Oil Company, has been elected to his fifth term as chairman of the National Petroleum Council. R. G. Follis, head of Standard Oil Company of California, was reelected vice president, with A. Jacobsen, president of Amerada Petroleum Corporation, named chairman of the council's agenda committee, succeeding the late George A. Hill, Jr., Houston.

Socony-Vacuum Fellowship

Socony-Vacuum Oil Company, Inc., has awarded $2000 to the department of chemistry and chemical engineering, Lehigh University, Bethlehem, Pa., to establish a fellowship in instrumental analysis during the period from Feb. 1, 1950, to Feb. 1, 1951.

Nearly a score of fellowships are being supported by the company during the 1949-50 academic year at a total cost of almost $40,000.

Sinclair Refining Names Assistant Refineries Head

Sinclair Refining Company has appointed Thomas B. Kimball assistant manager of refineries. Kimball, a 1923 graduate of the University of California in (B.S. in chemical engineering), first joined Shell Oil Company in plant training and practices, and then Sinclair's research and development department at East Chicago, Ind., where he was in charge of the cracking division and of the process engineering and development of light-oil processes. Since 1943 he has been technical assistant to the vice president of manufacturing in the New York office. During the past several years he has developed numerous patents on light oil treating and on thermal and catalytic cracking.

T. B. Kimball

"SUNRAY" IS BORN—The old name, "Beckett," disappeared from the Rock Island siding south of Duncan, Okla., January 14, when the point, serving gasoline tank car shipments from Sunray Oil Corporation's catalytic cracking refinery, was renamed "Sunray".

The oil company, formerly owned and operated a gasoline plant and a refinery at Altman, Texas, and this community, changed its town name to Sunray in 1933. Sunray Oil Corporation has since disposed of its gasoline plant and refinery in Texas.

The picture shows, Rock Island's Harry Bennett, local agent at Duncan; R. C. Underwood, Sunray, assistant refinery superintendent, driving the name panel post; and L. L. Humphreys, right, president of the Security National Bank, Duncan.

Independent Refiners Organized for 1950

Organization of the Independent Refiners Association of America for 1950 was completed at a meeting in Tulsa last month of the executive committee and directors with Harry Leyendecker, vice president of Eastern States Petroleum Company, elected president. Vice presidents named were James P. Dunnigan, president, Producers Refining Company, West Branch, Mich.; M. Lloyd Freese, vice president of Bell Oil and Gas Company, Inc., Tulsa; and M. H. Robineau, president of Frontier Refining Company, Denver. D. W. Hovey president, Danaho Refining Company, Houston, was elected secretary-treasurer. The board of directors is comprised of the above men and Fred C. Koch, president, Wood River Oil & Refining Company, Inc., D. E. Foster, president, Wisconsin Oil Refining Company, Sheboygan, Wis., and Robert O. Anderson, president, Malco Refineries, Inc., Roswell, N. M.

Purposes of appointed committees are to study and recommend policies on the following: 1) proration rules and regulations now adopted by various states as to natural gas, condensate, and crude oil; 2) the effects of export markets and crude and petroleum products imports on the domestic crude and petroleum products supply processed by the independent refiner; 3) the effect of recent actions of the dollar and sterling countries on market outlets for the independent, plus the action domestic government has taken in setting up agreements with other countries; 4) the screening of various published reports having an effect on independent refiner economy; the study of the transportation phase of crude and finished products, including overland and water transportation and transportation facilities

The MONTH...

available to the independent; 5) tariffs, rates, and taxes set up under national and local standards; and 6) the position the IRAA should assume in national government problems relative to the independent.

Other committee objectives are the preparation and submission to the board of an analysis on the principles generally used in establishing the value of crude oil, condensate, and gas by the purchasing companies, including an analysis of the crude gravity differential established by these companies. The association also plans an educational campaign among producers and royalty owners to demonstrate the advantages of the independent refining industry in maintaining an open and competitive market for their product.

New Blaw-Knox Department Changes Fuels to Chemicals

Blaw-Knox Company has formed a chemicals and fuels synthesis department for the conversion of fuels into chemicals, work to be based initially on the Fischer-Tropsch synthetic fuels process and on related processes for making synthesis gas.

The department, to be staffed by engineers in the company's chemical plants division, will adapt processes, develop pilot plants, design equipment, provide engineering and build plants for the conversion of plentiful fuels into more valuable chemical materials and upgraded forms of hydrocarbons.

The company has completed agreement with Ruhrchemie and Lurgi for licenses and access to all process information developed by these German firms. Ruhrchemie pioneered development of the Fischer-Tropsch process as used in Germany's manufacture of gasoline from synthesis gas obtained from coal. Lurgi built plants of this type in Germany and contributed to coal gasification.

THE OIL MAN'S CALENDAR

1950	
FEB.	
12–16	American Institute of Mining and Metallurgical Engineers, Annual Meeting, New York, Hotel Statler.
15–17	Spectroscopy Society of Pittsburgh, Conferences on Analytical Chemistry and Applied Spectroscopy, Pittsburgh, William Penn Hotel.
20–24	American Society for Testing Materials, Committee, D-2 on Petroleum and Petroleum Products, Spring Meeting, Washington, D.C., The Shoreham Hotel.
25	Western Petroleum Refiners Association, 1st Regional Technical Meeting, Shreveport, Texas, Washington-Youree Hotel.
27 to Mar. 2	American Society for Testing Materials, Pittsburgh, William Penn Hotel.
MAR.	
6– 9	American Road Builders Association, Annual Meeting, (Including Airport Division), Cincinnati, Netherlands Plaza Hotel.
13–16	National Electrical Manufacturers Association, Chicago, Edgewater Beach Hotel.
27–29	Western Petroleum Refiners Association, 30th Annual Meeting, San Antonio, Plaza Hotel.
APRIL	
3– 5	Society of Automotive Engineers, Aeronautic and Air Transport, New York, Hotel New Yorker.
4– 7	National Association of Corrosion Engineers, Annual Conference and Exhibit, St. Louis, Jefferson Hotel.
5– 7	Illinois Institute of Technology, Midwest Power Conference, Chicago, Sherman Hotel.
10–14	American Society of Mechanical Engineers, Washington, D.C., Hotel Statler.
11–13	Southwestern Gas Measurement, Short Course, Norman, Okla., University of Oklahoma.
12–14	National Petroleum Association, Cleveland, Ohio, Hotel Cleveland.
24–25	Industrial Accident Prevention Association, Toronto, Canada, Royal York Hotel.
24–26	Natural Gasoline Association of America, Annual Convention, Fort Worth, Texas, Texas Hotel.
24–26	American Society of Mechanical Engineers, Process Industries, Pittsburgh, William Penn Hotel.
MAY	
1– 4	American Petroleum Institute, Division of Refining, Mid-Year Meeting, Cleveland, Ohio, Hotel Cleveland.
7– 9	Independent Petroleum Association of America, Twenty-first Mid-Year Meeting, Los Angeles, Biltmore Hotel.
8– 9	American Gas Association, Natural Gas Department, Spring Meeting, Tulsa, The Mayo Hotel.
9–11	Liquefied Petroleum Gas Association, Annual Convention and Trade Show, Chicago, Palmer House.
1950	
MAY	
15–17	Oil Industry Information Committee, Chicago.
15–18	National Fire Protection Association, American Gas Association Exhibit, Atlantic City, N. J., Haddon Hall.
29–31	Texas College of Arts and Industries, Fifth Annual Short Course in Gas Technology, Kingsville, Texas.
JUNE	
4– 9	Society of Automotive Engineers, Summer Meeting, French Lick, Ind., French Lick Spring Hotel.
12–16	American Institute of Electrical Engineers, Summer and Pacific General Meeting, Pasadena, Calif., Huntington Hotel.
12–16	American Society of Mechanical Engineers, Oil and Gas Power Division, Baltimore, Md., Lord Baltimore Hotel.
12–16	American Society of Mechanical Engineers, 4th National Materials Handling and Exhibit, Chicago, International Amphitheater.
15–16	Pennsylvania Grade Crude Oil Association, Annual Meeting, Pittsburgh, Hotel William Penn.
18–20	Petroleum Equipment Suppliers Association, White Sulphur Springs, W. Va., The Greenbrier.
26–30	American Society for Testing Materials, 53rd Annual Meeting, 9th Exhibit of Testing Apparatus and Related Equipment, Atlantic City, N.J., Chalfonte-Haddon Hall.
SEPT.	
5– 9	American Chemical Society, 6th National Chemical Exposition by Chicago Section, Chicago, Chicago Coliseum.
11–15	American Society of Mechanical Engineers, Industrial Instruments and Regulators Conference with the Instrument Society of America, Buffalo, N. Y., Municipal Adultorium.
25–27	American Society of Mechanical Engineers, Petroleum Mechanical Engineering Division, New Orleans, The Roosevelt.
OCT.	
2– 6	American Gas Association, Annual Convention, Atlantic City, N.J.
16–20	National Safety Congress, National Safety Council Exposition, Chicago.
NOV.	
2– 3	Society of Automotive Engineers, Diesel Engine Meeting, Chicago, Hotel Knickerbocker.
9–10	Society of Automotive Engineers, Fuels and Lubricants Meeting, Tulsa, Okla., The Mayo.
11–13	Oil Industry Information Committee, Los Angeles, Biltmore Hotel.
13–16	American Petroleum Institute, 30th Annual Meeting, Los Angeles, Biltmore Hotel and Ambassador Hotel.
15–17	National Electrical Manufacturers Association, Atlantic City, N. J., Chalfonte-Haddon Hall.

California Research Names Three Patent Managers

Appointment of A. L. Snow as manager of the patent department, and his election as a vice president, has been announced by California Research Corporation, a subsidiary of the Standard Oil Company of California. He succeeds J. N. Adams, a vice president of the research company, retired after 31 years of service with the corporation. Other patent department appointments include O. S. Loud and H. B. Wands, Jr., as assistant managers.

Snow

Snow joined Standard (California) as a patent attorney in 1935, after five years with the United States patent office in Washington and has served the company as senior patent attorney in charge of chemicals, and assistant manager of the patent department.

Phillips Achieves Accident-Free Hours

Employes at Phillips Oil Company's refinery at Phillips, Texas, have completed one million man hours without time lost due to injuries, the second such accomplishment at the refinery in the past 13 months. The record covered a period of 159 days since an injury to an employe caused him to lose time from his job. The refinery employs more than 1000 workers and operates on 'round-the-clock schedules.

G. E. McKenna is superintendent and A. W. Sweeney, plant safety director.

Stanolind Safety Record

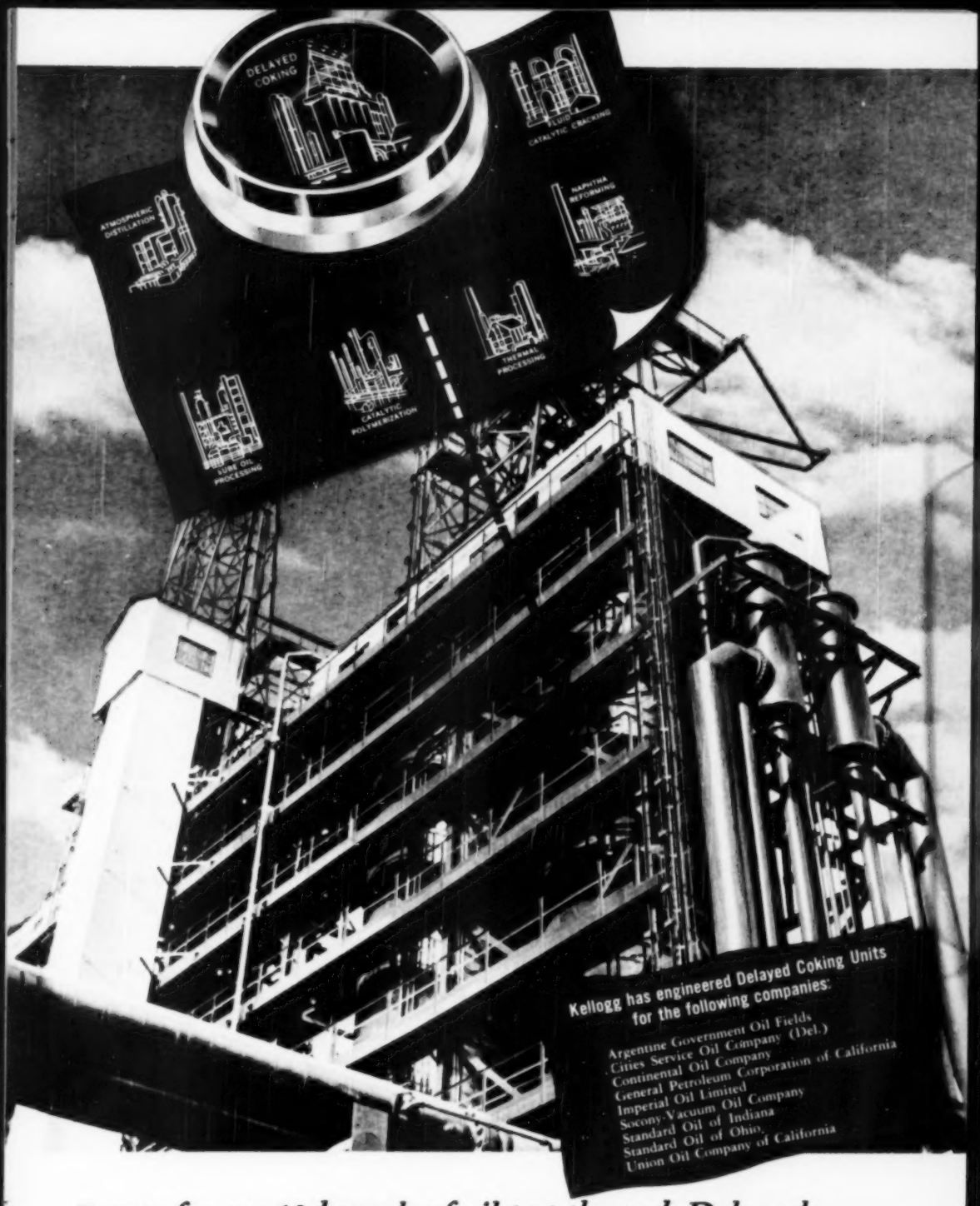
Stanolind Oil and Gas Company's 7004 employes worked a total of 14.9 million hours with 48 lost-time accidents during 1949. This resulted in a new safety record for the year with an accident frequency rate of 3.22, as compared with the company's previous record low of 3.39, established in 1948. The frequency rate indicates the number of disabling injuries for each million man-hours of work. The National Safety Council reported that in 1948, the petroleum industry as a whole had a frequency rate of 12.27.

New Missouri Offices

The C. W. Nofsinger Company announces opening of its offices, 243 Lathrop Building, Kansas City 6, Mo., to serve petroleum, chemical and general industry, with consulting, engineering and contracting services.

Rubber from Turpentine

A new type of high-quality synthetic rubber, made with a chemical derived from turpentine, has been reported by scientists of the Bureau of Agricultural and Industrial Chemistry. This achieve-



7 out of every 10 barrels of oil put through Delayed Coking Units go through Kellogg-built equipment...

. . . YES! Kellogg has built better than 70% of the world's total Delayed Coking Capacity . . . with more coming!

NO LONGER is there any question of the importance of Delayed Coking in the economics of modern refining. And there are three good reasons for this: 1. The softening of fuel oil requirements; 2. The ever-increasing demand for clean catalytic cracking feed; 3. The increasing demand for high quality process coke.

The only question remaining is, "*Who* will build the necessary Delayed Coking capacity?"

Kellogg submits its 70% capacity record for your consideration. There must be definite reasons behind such a commanding position, particularly when it has been maintained over a ten year period.

When you are evaluating Delayed Coking, Kellogg would welcome the opportunity to discuss the specifics of its application to your refinery.

FURNACE DEVELOPMENT IS KEY TO SUCCESS OF KELLOGG UNITS

Today's Delayed Coking is essentially founded upon the efficiency of the furnace itself. Here, the charge stock must be heated to the necessary temperature quickly and then rapidly moved into the coker drums before it "cokes up" the furnace tubes. Thus it is obvious that furnace design is directly responsible for the length of on-stream runs.

It isn't surprising, then, that Kellogg, which has been intimately associated with thermal cracking since its earliest days in the 1920's, and has built literally hundreds of thermal units, should now be designing Delayed Coking units whose runs are exceeding *eight months*. Even then, inspections have shown that units *might have been kept on stream for longer periods without appreciable loss of efficiency.*

IT TAKES ALL SEVEN TO PRODUCE GREATER EARNING POWER . . .

1 THE DEVELOPMENT "TOOLS" —laboratories, pilot plants and recognized specialists to prove and improve processing and equipment ideas.

2 PROCESS ENGINEERING by men with the experience and the available data to develop new methods, beyond established procedures, in order to obtain maximum efficiency in a specific operating situation. At Kellogg THREE distinct groups of specialists are brought to bear on every processing problem. *First*, the sequence engineers, who weigh the over-all economics; *Second*, the unit engineers, who specialize in improving specific processes; *Third*, the development engineers, who continually contribute to the technical advance of oil refining processes. The combined effort of these three talents is bound to produce process plans with greater earning potential.

3 SPECIALISTS IN EVERY PHASE of design engineering due to the completeness of Kellogg's engineering staff.

4 SPECIALIZED BUYERS backed by the cumulative buying power of the largest company in the business.

5 COMPLETE FABRICATING FACILITIES to make schedule deadlines and to develop workable "firsts" in refinery equipment.

6 CONSTRUCTION KNOW-HOW acquired in completing hundreds of major jobs, plus an ample supply of the proper tools, and the constant development of new money-and-time-saving methods on the construction lot.

7 PRACTICAL OPERATING COUNSEL on all design and construction, achieved through practical operating men working as an integral part of the company.

. . . AND ONLY KELLOGG HAS ALL SEVEN!

The M. W. Kellogg Company, (a subsidiary of Pullman, Inc.), New York, Jersey City, Los Angeles, Tulsa, Houston, Toronto, London, Paris

ment, a result of work begun during the war by the bureau's naval stores research division, is said to make it possible to use turpentine as a supplementary source of synthetic rubber in a national emergency. Under present conditions rubber from turpentine is somewhat more costly than GR-S, the most common synthetic rubber now produced commercially. The new synthetic, compounded for use in tires, is claimed to be slightly stronger than GR-S rubber, stretch better, and generate less heat under stress.

Main ingredient of the new elastomer is isoprene, a compound that forms the basic molecular unit of natural rubber. It is obtained from turpentine by a special molecule-splitting process developed by bureau researchers. Isoprene produced from petroleum is already used in some types of synthetic rubber now on the market. The bureau's method of producing it from turpentine may be a valuable national asset in the event of emergency shortages of petroleum.

Sohioan Becomes First Senior Vice President

A. A. Stambaugh, since 1933 the vice president in charge of sales and a director of The Standard Oil Company (Ohio), has been elected the company's first senior vice president. He is also general sales manager. Nationally recognized as an authority in the petroleum marketing field, Stambaugh joined Sohio as director of industrial relations in 1928. He served in industrial relations at Sohio, as sales manager, director, and vice president. He will continue in charge of all sales activities of the company.

Stambaugh

Small Refiner Losses On Crude Barrel Price

A small refiner who purchases all or a major portion of his crude supply continues to lose about 17 cents per barrel on crude processed, according to a study of refinery operations concluded by Western Petroleum Refiners Association. With burning oil prices higher than for the last half 1949, total realization still is insufficient to offset losses, the association says.

Similar to the report issued in May, 1949, the study includes investigations of refinery operations relative to product yields, operating costs and realization of plants located in Kansas, Oklahoma and North Texas, having crude capacities of 4000 to 8000 barrels per day and equipped with skimming and thermal cracking.

Bond & Share Planning Petrochem Investments

Electric Bond & Share System has disclosed to the Securities and Exchange Commission its intention to retain a 27 percent interest in United Gas Corporation, so that the two companies can go into partnership in the chemical petrochemical field. Bond & Share received 2.8 million shares of United Gas common stock some months ago through the dissolution of an intermediate holding company, Electric Light & Power Company. SEC said Bond & Share would have to divest this stock in 12 months, unless it submitted a proposal for reconsideration and won SEC approval.

Curtis Calder, chairman of Bond & Share, said the company planned to invest $25 million in a joint new venture in the Gulf-South area. He said Bond & Share and two affiliates it plans to retain when it is transformed into an investment company—American & Foreign Power Company and Ebasco Services, Inc.—together with United Gas, National Research and perhaps some chemical concern as a partner, have all the ingredients neccessary for the successful exploitation of these natural gas reserves in the petrochemical field.

New Machine Will Figure Fractionating Tower Data

An automatic "thinking" device which can figure out the performance of multi-component fractionating towers in a fraction of the usual time has been developed at Northwestern University, Evanston, Ill.

According to O. W. Goetz and J. F. Calvert, of Northwestern, this "analogue computer," now in operation, will ease considerably the "tedious trial and error computations that have been employed in designing and pre-determining the performance of multi-component fractionating columns."

"Primarily, the computing machine is composed of resistors, potentiometers and amplifiers, suitably chosen and connected to yield the electrical representation of equations, though in slightly modified form," Goetz said. A 400-cycle carrier voltage is applied to a number of channels. One channel is required for each chemical component to be represented; and while six are provided in the present machine, this is not a basic design restriction. Each channel is composed of a number of circuits, along which the voltage is multiplied by the appropriate factors. At various locations, voltage signals are added and subtracted as required by the plate-to-plate equations."

The machine, according to Goetz, can be employed not only on the design of new equipment, but also on the study of possible design and feed variations which might be made in existing fractionation columns.

ECA Cutbacks Funds For British Refinery

ECA has cutback to $2.5 million the $10 million it had originally set for the financing of Britain's Shell Haven refinery. Under a revised project application, announced by ECA, the refinery near London, will now cost a total of $34 million instead of the previously estimated $58.4 million.

The new distillation capacity to be installed has been reduced from 66,000 to 40,000 barrels per day. Also a previously proposed cat cracker is to be eliminated. At present, the project calls for the installation of a reforming plant, a polymerization plant, and necessary treating plants. ECA funds will be used for the purchase of special materials and equipment in the United States.

The MONTH...

General Motors Researcher To Receive Engineers Medal

T. A. Boyd, consultant for General Motors Corporation's research laboratories, was awarded the Society of Automotive Engineers Horning Memorial Medal, January 11, during the 1950 annual meeting in Detroit. The medal was being presented in recognition of his paper "Pathfinding in Fuels and Engines," selected as the "best paper on the adaptation of fuels to internal combustion engines."

Boyd

Boyd, who helped to develop tetraethyl lead used in ethyl gasoline, was also one of the team which developed triptane for advanced engine research. The fuel has a knock rating of more than three times that of 100 octane airplane engine gasoline.

Synthetics Liquid Fuels Extension to Be Asked

With the present program due to expire June, 1952, the Interior Department is expected to ask Congress to extend its synthetic liquid fuels research program for another five years and to seek authorization for expansion expenditures of $35 to $40 million.

The department's Office of Synthetic Liquid Fuels' annual report containing detailed analysis of costs of producing liquids by oil-shale and coal-hydrogenation processes was to have been completed early this month.

Sinclair Scientist Honored

Dr. Herman Elkan Ries, Jr., announced winner of the Ipatieff award and head of the physical chemistry department of Sinclair Refining Company's research laboratories at Harvey, Ill., was honored at a dinner last month in Chicago. Dr. Ries is the second chemist to receive the award which will be given at the 117th national meeting of the American Chemical Society in Houston, this spring.

Dr. Ries, research scientist at the company for 13 years, is cited for his contributions to the knowledge of catalysts, particularly those used in petroleum hydrocarbon conversion.

NPC to Study Natural Gas

National Petroleum Council has been requested by the Interior Department to study and make a report on the present inter-relationships between natural gas, fuel oil and coal by geographic areas, together with a statement of the prob-

The MONTH...

able future trends. Primary purpose is to develop basic data on which to determine the influence spreading supplies of natural gas are going to have on the demand for fuel oil and how that will affect oil production.

Long-Time Employes Retire As Executives of Gulf

Henderson Slater

Vice presidents William A. Slater and Herbert Henderson have retired after 42 years of service with the Gulf companies. J. G. Glashow, manager of engineering and construction for the manufacturing department, who has been with Gulf Oil Corporation for 40 years also is retiring.

Asphalt Institute Elects

Grayson Gray

The board of directors of The Asphalt Institute has elected Bernard E. Gray president and Ingram Grayson, chairman of the executive committee. Other executive committeemen are N. H. Angell, Stancal Asphalt and Bitumuls Company; J. N. Byrd, Mexican Petroleum Corporation; P. C. Doyle, Standard Oil Company (Ohio); H. B. Pullar, Berry Asphalt Company; R. S. Ketcham, Col-Tex Refining Company; Harold R. Pauley, The Petrol Corporation.

New members elected were American Bitumuls Company of San Francisco and Cosden Petroleum Corporation of Big Spring, Texas.

Newly elected vice presidents with their respective divisional jurisdiction are Atlantic-Gulf, J. N. Byrd, division I; P. C. Doyle, Ohio-Great Lakes, division II; H. B. Pullar, Midwest, division III; R. S. Ketcham, Southwest, division IV; Harold R. Pauley, Pacific coast, division V.

Herbert Spencer was re-elected secretary of the institute, George R. Christie and John N. Smith, both of Socony-Vacuum Oil Company, Inc., treasurer, and assistant-treasurer, respectively.

First of Standard Oil Companies Observes 80th Anniversary of Founding

January 10, 1950, was the 80th birthday of The Standard Oil Company (Ohio) once world-wide in its operations, but today an independent oil company serving the people of the state of Ohio.

The group of Clevelanders who incorporated the company in 1870 chose The Standard Oil Company as a name because then there were no standard specifications in the industry and they wanted to assure customers that their products would be of standard quality.

During its first 12 years, this company was the parent company of an organization that for awhile made Cleveland the world's oil center. As other properties were acquired, separate companies were organized to own and operate them and the stock of these companies was taken, not by The Standard Oil Company itself, but by trustees who held it for the benefit of the parent company and its stockholders. In 1882, The Standard Oil Trust was created, and the trustees were the directors of The Standard Oil Company in Cleveland. The Standard Oil Company stockholders exchanged their shares of Standard Oil Company capital stock for shares of beneficial interest in The Standard Oil Trust. Sohio, the parent organization, became a subsidiary for a few years.

In 1899, because New Jersey had broadened and liberalized its corporation statutes, the assets of The Standard Oil Trust were transferred to The Standard Oil Company of New Jersey. In 1911, the United States Supreme Court issued a dissolution decree, ordering The Standard Oil Company of New Jersey to divest itself of ownership in some 33 subsidiaries, among which was Sohio.

Thus, The Standard Oil Company, in Ohio, came back to its original state as an independent Ohio company, but it owned nothing more than a 5000-barrel refinery, a string of bulk stations, a fleet of tank wagons and a marketing business confined to the state of Ohio.

Since 1911 Sohio has followed a long, steady program to expand and integrate its facilities to meet the ever-growing needs of its customers within the limited area of the single state which it serves. This program has included the expansion and modernization of its refining capacity, the establishment of direct connections with oil producers in the fields, the building of gathering lines, and the building of pipe lines to its refineries.

All this took tremendous capital. It was not until the latter part of 1942 that the company was able to muster the resources to begin to build up its own crude oil production. Some idea of the cash required for business may be seen in the five-year period between 1944 and 1948:

Replacement and Expansion of Plant Facilities	$117,817,000
Working Capital (Growth in Operations)	47,041,000
Other Investments	1,961,000
Retirement of Stock and Financing Costs	4,274,000
Total Cash Requirements of the Business	$170,193,000

Funds provided from Sohio operations during those five years amounted to $91,691,000 and the remaining $78,502,000 needed had to be supplied by new stock issues and borrowings in the amount of $61,382,000 and from other sources.

Today Sohio employs between 10,500 and 11,000 people and has some 19,000 stockholders. The number of stockholders has doubled in the last four years. One hundred nineteen charitable, educational and religious institutions and associations own more than 11 percent of Sohio's stock; trust departments of banks and trust companies representing hundreds of estates, more than 11 percent; and investment companies, whose shares are held by thousands of owners, more than 6 percent.

As an independent company, free from connection with or domination by any other company, whatever its name, The Standard Oil Company (Ohio) competes in Ohio with five other former subsidiaries of Standard of New Jersey, and, through companies named Sohio and Fleet-Wing, it competes outside the state of Ohio in crude oil procurement and sales to jobbers.

Bureau's Cost of Oil to Shale 7.3 Cents Gallon

The Bureau of Mines now estimates the actual cost of producing liquid fuel, in terms of total products realized, from oil shale in a 10,000-barrel-per-day plant, at about $3.07 per barrel or 7.3 cents per gallon, assuming an 87 percent yield through the refinery. This includes all direct and indirect costs and allowing for amortization of $42 million plant investment over a 15-year period, with annual profit after taxes of 6 percent on the unamortized portion. The bureau also figures that on such a basis, the necessary refinery realization per barrel of finished product must average approximately $3.78, or 9 cents per gallon.

From these calculations, based on operation of the shale oil demonstration plant at Rifle, Colo., the bureau is to report to Congress its belief that commercial production of liquid fuels from oil shale has moved into the economic range of products made from petroleum.

New Petrochemical Firm

Specializing in the petrochemical field, a new construction firm known as Pioneer Industrial Company, Houston, has been formed by Harold W. Finney, long identified with construction in the oil and gas industry. Other members of the firm include C. W. Hoffman, R. D. Rockwell, J. D. Sherrill, and Jack E. Trainer. Temporary offices are located at 7043 Lawndale.

Du Pont Survey Shows Octane Ratings Are Up

Octane ratings were up in most of the 35 U. S. cities and two Canadian cities surveyed for a report completed by E. I. du Pont de Nemours Company, Inc.'s, chemicals division, showing comparison of premium and regular grade gasolines for January of this year with May, 1949.

Five cities showed average octane rating below either May or October of last year for premium gasolines. For regular grade octane rating, averages in seven cities showed drop, with all others in-

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared by Bridgeport Brass Company "Bridgeport" *Headquarters for BRASS, BRONZE, and COPPER*

Use of Increased Water Velocity Helps Keep Condenser Tubes Clean

Large fouling organisms and certain slimes on condenser tube surfaces can be controlled by increased water velocities through the tubes. At water velocities over one to three feet per second most marine life cannot attach itself to tube surfaces. Higher velocity may also aid in preventing certain suspensions of industrial origin, wastes, etc. from adhering to the tube surface.

Dangers of Fouling

Where debris partially blocks off tubes for any length of time, the water velocity through the tubes affected may drop sufficiently to allow fouling organisms to attach themselves.

Once marine organisms have gained a foothold, higher water velocities will not dislodge them.

Difficulty can be anticipated in condensers and heat exchangers operating at low water velocities, using water containing embryos of marine organisms. The organisms which attach themselves to condenser tubes vary considerably with localities.

The difficulties encountered due to organisms in tubes, on tube sheets and water boxes occur chiefly along four lines. First, blockage of condenser tubes markedly reduces the heat transfer of the condenser. Secondly, large masses of marine growth may restrict the flow of water so seriously that a high back pressure may damage pumps and associated piping. Third, during periods of shutdown incomplete removal of dead organisms will initiate corrosion pitting. Fourth, in the chemical and petroleum processing fields, such blocking of tubes can produce even greater complications. Often the heat of the products being cooled is so high that if this heat is not carried away immediately by the cooling medium, the metal in the tubing will be greatly expanded. This thermal expansion in certain instances has caused permanent distortion, buckling, breakage and loosening of tubes in tube sheets. Not only is costly maintenance involved but leakage naturally causes contamination of the products.

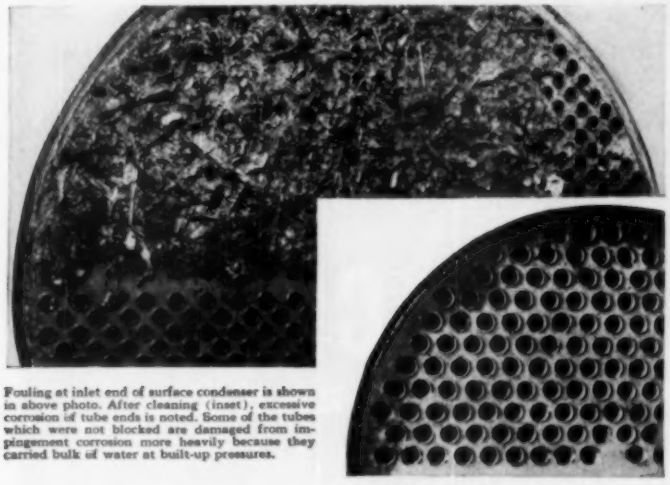
Other Effects of High Velocities

The use of high water velocities is also beneficial in preventing clays, hydrated iron oxides, hydrated aluminum oxides and other materials from attaching themselves to the tube walls. Sometimes water velocities in excess of seven feet per second and approaching 10 or 12 feet per second, appear to be required to prevent the deposition of certain suspended materials from the water on to tube surfaces. For various reasons it is not always feasible to attain these high water velocities.

The use of water velocities in the order of five to seven or more feet per second requires the use of settling basins, screens or strainers in order to eliminate debris from the water before it reaches the condensers.

Where water velocities in excess of six or seven feet per second are contemplated to keep tubes clean, it is advisable to proceed with caution since considerable damage can occur over a short period of time due to impingement corrosion at the inlet ends of condenser tubes or where the water flows around objects lodged in condenser tubes. In fact, even at six and seven feet per second, the finest and most corrosion resistant copper-base alloys are vulnerable to attack under such adverse conditions.

In some inland power plants water velocities as high as 10 feet per second have been used to keep condenser tubes clean and maintain high heat transfer rates. This has been possible where relatively little sand was suspended in the water, in the absence of debris and where the composition of the water was such that it was non-corrosive toward copper-base condenser tube alloys.



Fouling at inlet end of surface condenser is shown in above photo. After cleaning (inset), excessive corrosion of tube ends is noted. Some of the tubes which were not blocked are damaged from impingement corrosion more heavily because they carried bulk of water at built-up pressures.

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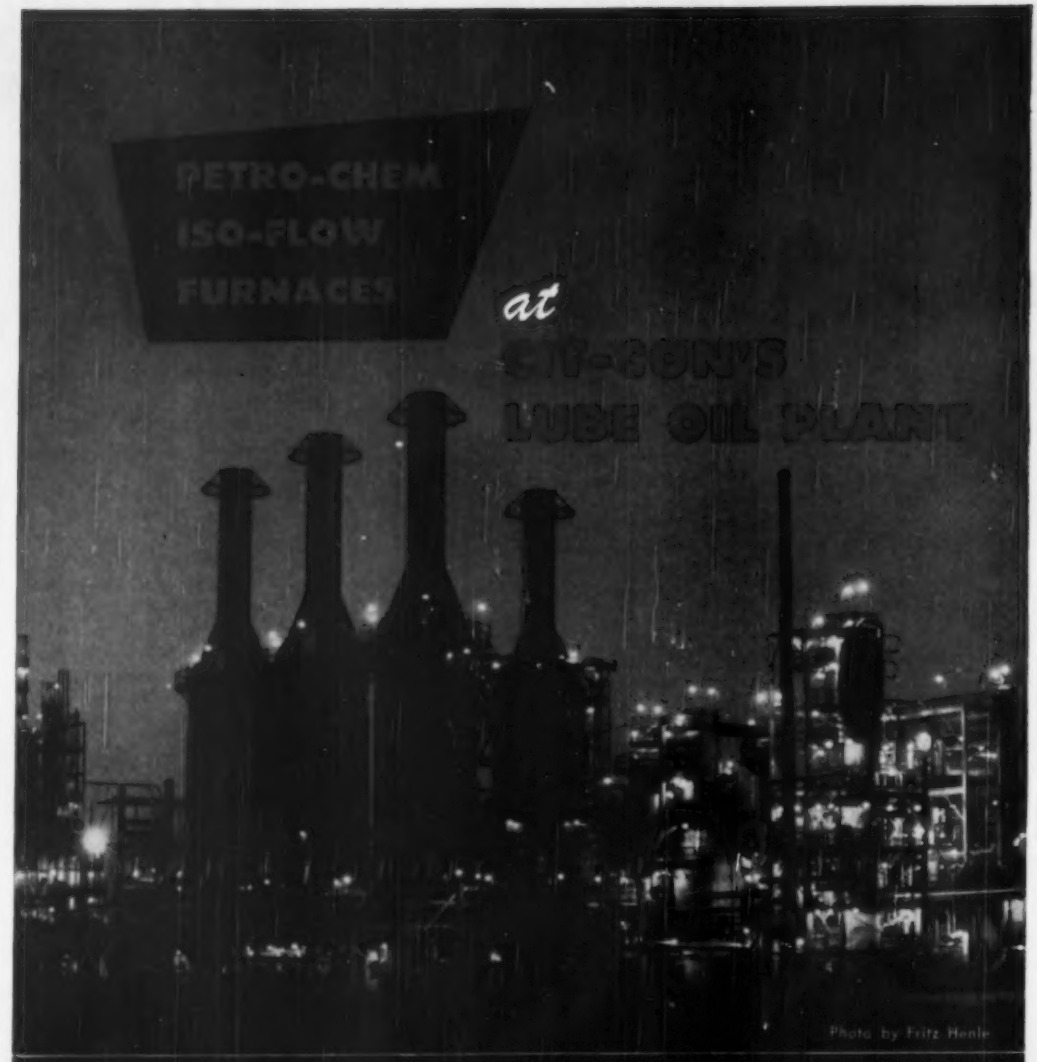

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creasing. Average premium octane rating of gasolines sampled in 10 cities ranged from 90.0 to 91.5. Highest rating, 91.5, was given San Francisco. Samples in only one city, El Paso, Texas, (84.2), showed average octane rating of below 85. Average octane numbers for regular grade gasoline in four cities were over 85 and three were below the 80 mark.

Names in the News

Sanford M. Wagner has been elected vice president in charge of sales, New York office, Ethyl Corporation. Wagner, formerly in charge of sales operations in the western region, has been with the corporation for 24 years, serving as organizer of sales and service activities on the west coast, and Los Angeles division manager. In 1945, when the sales department was reorganized on a regional basis, Wagner was named western region manager. He was graduated from Rensselaer Polytechnic Institute in 1912.

Wagner

Robert E. Donovan, manager, safety division, Standard Oil Company of California, is the new president of the Veterans of Safety, an organization comprising professional safety engineers who have served for at least 15 years in their field.

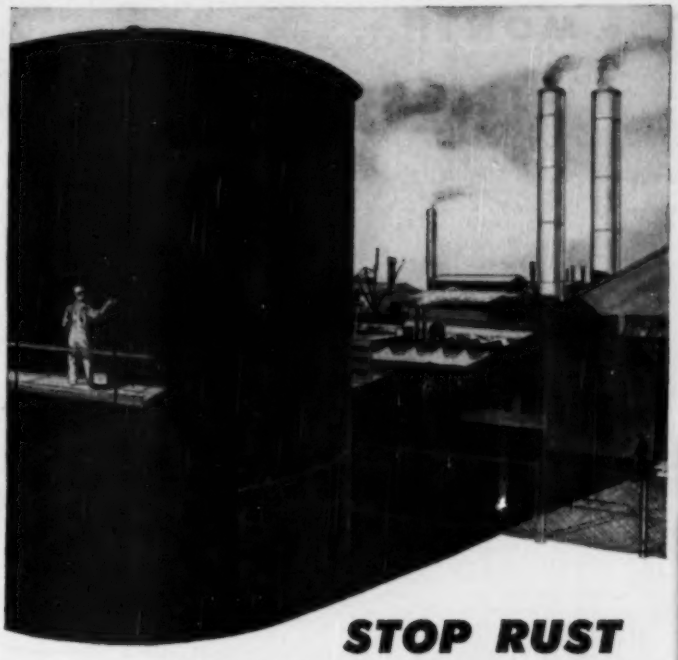
F. F. Elliott has been elected assistant treasurer of Standard Oil Company (Indiana). Elliott, who joined the company in 1930, was formerly supervisor of the annuity trust department.

Ed Wrangle, Seminole, Okla., has been named superintendent of the new Chico, Texas, gasoline plant of Cities Service Oil Company, which went on stream last month. He formerly was superintendent of the Sasakwa plant in the Seminole, Okla., field. **E. B. Lord** of Seminole will handle supervision of both the Maud and Sasakwa plants, with **Lonnie Pitts** handling direction of Sasakwa plant operations as assistant superintendent.

Dr. J. W. Bertetti, chief engineer of the El Dorado, Ark., refinery of Pan-Am Southern Corporation since 1947, has been promoted to technical director with supervision of mechanical and chemical engineers and laboratory chemists and technicians. The move is to facilitate coordination of expansion and improvement programs now under way.

Richard Bard, formerly manager of Shell Oil Company's gas-gasoline department at Tulsa, has been made assistant manager of the crude oil department in charge of volatiles, New York. Bard is replaced in Tulsa by **Ruel Harris,** a member of the crude oil department in New York for the past year.

H. P. Hobart, vice president, has been named head of Gulf Oil Corporation's



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**Names on request*

If you have a rust problem, and would like a free survey and recommendations, send your name and address on your business stationery. A qualified factory representative will arrange this free service, which includes a trial size of Rust-Oleum for specific test purposes. There is no obligation on your part. Write today.

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The MONTH...

recently organized product development and product engineering section. Directing each of the three sections are **S. C. Levens,** appointed administrative assistant to Hobart; **C. J. Livingstone,** director of product development, responsible for maintaining maximum quality of products such as gasoline, fuel oil, and lubricating oils; **C. R. Noll,** director of automotive products engineering, who will be concerned with application of the products to automotive equipment; and **W. B. Shirk,** director of industrial products engineering, who will supervise application of fuels and lubricants in prime movers and industrial plants.

Edwin S. Hall, former vice president and general attorney of Esso Standard Oil Company, has retired after 30 years with the company.

Robert L. Grun has been appointed chief fuels and lubricants engineer, process oil section, industrial products engineering, Gulf Oil Corporation, Pittsburgh. Grun has been associated with the company since 1936.

J. J. Leu, manager of the services department, American Oil Company, has been elected vice president in charge of the services and operations.

H. J. Struth has resigned his post as assistant director of information for the API and is returning to Dallas, his former home, where he will open his own office as a petroleum consultant and economic advisor to various oil and gas organizations.

Industrial Process Engineers, Newark, N. J., has appointed **A. Brothman** consulting associate of the company. Brothman, chemical processing authority and author, heads the engineering firm of A. Brothman & Associates, Long Island City.

Pan American Refining Corporation names four personnel promotions as follows: **Roscoe Stahl,** chief, economic section of the research and development department; **William Kaplan,** technical service section head; **Frank Anderson,** section chief of process design; and **Robert Meuleners,** process design section group leader.

Lowell E. Ullery, a vice president, has been chosen successor to Joseph E. Pogue as executive head of the petroleum department of Chase National Bank. Pogue will continue as consultant to the bank on petroleum and natural gas.

John F. Hansen has been appointed assistant manager, special products department, Deep Rock Oil Corporation. He has served Mallinckrodt Chemical Company and Shell Oil Company as a chemist in the Wood River, Ill. refinery. He was transferred to the latter's St. Louis sales division, serving as assistant to the special products manager before joining Deep Rock.

Fletcher B. Emerson has been named director of a newly-created training division within the industrial relations department of Continental Oil Company, Ponca City, Okla. He was formerly assistant to L. F. McCollum, president.

Norval F. Myers will head the refining activities in United Kingdom as director of Anglo-American Oil Company, Ltd. He was formerly with Standard Oil Development Company.

P. W. Thirtle, vice president of Sinclair Oil Corporation, and general auditor and comptroller since its formation in 1916, has replaced Alvin Untermyer, resigned, as a member of the board.

Guy L. Tate, Magnolia Petroleum Company, Dallas, has been elected a vice chairman of Oil Industry Information Committee.

Oronite Chemical Names Researcher Executive

Election of H. E. Bramston-Cook as a vice president has been announced by Oronite Chemical Company, subsidiary of Standard Oil Company of California. He will continue as general manager of sales and product development work east of the Rockies.

Bramston-Cook

Bramston-Cook has been a lecturer in chemistry at the University of British Columbia, where he also received his B. S. and M. S. in applied science. Since 1946, he has been with Oronite Chemical Company as a sales manager and eastern general manager. Previously, he was employed with Union Oil Company of California as a research chemist, assistant superintendent, refined oil division, and supervisor, lubricating oil division, Oleum refinery; and manager, technical products department in head office sales.

Heads Rubber Subcommittee

Representative Vinson (D., Ga.) of the House armed services committee will serve as chairman of the subcommittee to review President Truman's recommendations for maintenance of government controls over synthetic rubber industry and for disposal of government-owned synthetic plants.

The Senate Interior Committee's recent indorsement of the nomination of Acting Interior Secretary Oscar L. Chapman as Secretary of the Interior now goes before the Senate for approval. Chapman said that the synthetic fuels research program must be continued past the 1952 expiration date.

New Gasoline Plant

The Railroad Commission has authorized Coastal Refineries, Inc. and Mayfair Minerals, Inc. to build a gasoline extraction plant and gas cycling system for the McAllen field, Hidalgo County, Texas.

Plans for Puerto Rico's Initial Oil Refinery Being Prepared in U. S.

A group of American citizens is completing plans for the construction of Puerto Rico's first oil refinery, a plant which will play an important part in the industrialization program of that island and in the petroleum distribution system of the Caribbean area. Names of the sponsors of the project have not yet been disclosed, but it is understood that all funds will come from continental United States. Gov. Luis Munos Marin states that full details of the refinery project, including names of all top operating and management personnel, will be made public before final approval is given.

Contracts are being drawn for erection of the plant to cost between $20 and $25 million. It will be operated by Puerto Rican Oil Refining Company, Inc., on a plant site at Guayanilla, near Ponce. Headquarters of the company itself are at Tallaboa, Peneules, Puerto Rico.

The refinery will have a daily maximum throughput of 25,000 barrels and will produce gasoline, kerosine, distillate and residual fuel oils. Later some small cracking facilities are expected to be added.

William Eberle, partner of the contracting firm of Lyford and Eberle, New York, in charge of the project, says that construction work will begin in 60 to 90 days and scheduled completion date is sometime before mid-1951. The over-all engineering work is being handled by Parsons, Brinckerhoff, Hall and Macdonald, of New York, who have been assisted in the preparatory stage of the work by Roy Hanwood Associates, New York. About a half dozen engineering sub-contracts are expected to be awarded late in February, according to Eberle.

The plan is to operate the plant virtually wholly on Venezuelan crude oil with perhaps supplemental shipments from Colombia. However, sponsors of the project are concerned over pending legislation in the House of Representatives to tax crude imports into the United States. If Puerto Rico, which is considered fully U. S. territory, should be included in any such legislative action, the refinery would be severely handicapped in obtaining charge stock.

Puerto Rico's increasing need for petroleum products has been met up to the present time by imports into the island by Standard Oil Company (New Jersey), The Texas Company and Shell interests from Curacao, Maracaibo and Aruba. The new refinery would come under the tax-exemption program of the Puerto Rican government intended to attract new and diversified industry to the island. Surplus petroleum products —which initially might run 40 million barrels annually would be sent to continental United States or to various consuming areas in the Caribbean basin. A key point in Gov. Munoz Marin's approval of the final plans is that there be no discrimination in the distribution of the refinery's output, and that all companies now selling oil and gasoline in Puerto Rico would have the right to handle the plant's products at competitive prices.

THE price paid for Attapulgus and Porocel adsorbents is around *one cent* per pound—a fact which, we will agree, makes pretty dull reading. But for refiners using our materials, this modest investment pyramids to phenomenal returns. To be specific, each pound properly applied to petroleum stocks increases their value by at least *one dollar*—a return of 100 to 1.

Some four billion pounds of fullers earth and bauxite have been shipped to refineries by Attapulgus and Porocel—a noteworthy record of service to the industry. But what is even *more* noteworthy is the fact these materials have put four billion dollars into refinery purses—a point which makes *good* reading.

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SCIENCE and TECHNOLOGY Abstracts

Prepared by
DR. E. H. LESLIE and DR. H. B. COATS
The Leslie Laboratories
Traver Road, Ann Arbor, Mich.

Manufacture: Processes and Plant

Fractional Distillation of Multicomponent Mixtures. Number of Transfer Units. A. J. V. Underwood. *Ind. Eng. Chem.*, **41** (1949), pp. 2844-7.

The author develops equations for calculating the number of transfer units required for the fractionation of multicomponent solutions. It is assumed that relative volatility and molal reflux are constant. Bibliography of 12 references.

Plate Efficiencies in Separation of C_4 Hydrocarbons by Extractive Distillation with Furfural. E. W. Grohse, R. F. McCartney, H. J. Hauer, J. A. Gerster, and A. P. Colburn. *Chem. Eng. Progress*, **45** (1949), pp. 725-39.

Although plate efficiencies of 60 to 100 percent are considered common in conventional hydrocarbon distillation columns, it was observed that efficiencies of 20 to 35 percent are reported for commercial C_4 hydrocarbon extractive distillation columns employing furfural. Over-all plate efficiencies of about 50 percent have been reported for the separation of toluene from nonaromatics using phenol and extractive distillation. Since it appears that there would be considerable room for improvement in design of extractive distillation columns, a semi-work pressure extractive distillation unit was constructed at the University of Delaware. Plate efficiencies were determined in a 1.3-inch i.d., ten-tray, pressure distillation column used to separate isobutane from 1-butene in the presence of furfural and furfural-water solutions as the separating agents in an extractive distillation operation. Approximate ranges of average operating variables are given over the entire relatively wide range of operating variables studied. Murphree plate efficiencies varied between 47 to 61 percent. Corresponding local efficiencies varied from 39 to 51 percent. When computed on a common basis, only a relatively small difference in plate efficiencies was shown for the experimental column and the isobutane solvent towers at the Neches Butane Products Company. In the light of these results, it is difficult to reconcile the considerably lower efficiencies reported for the n-butane and butadiene solvent towers. Bibliography of 32 references.

Plate Efficiencies Related to Separate Vapor and Liquid Resistances. J. A. Gerster, A. P. Colburn, W. E. Bonnet, and T. W. Carmody. *Chem. Eng. Progress*, **45** (1949), pp. 716-24.

The investigators determined single-film plate efficiencies for a 13-inch diameter plate identical in design with the one used in a companion study of plate efficiencies in the separation of C_4 hydrocarbons by extractive distillation with furfural. The gas film efficiency was obtained by measuring the degree of humidification of air passing upward through water flowing across the plate at the wet bulb temperature. The liquid-film efficiency was obtained by measuring the amount of oxygen that could be desorbed from the water by the air. The effect of varying gas and liquid rates upon each film resistance is shown.

Convenient methods for combining single-film resistances in plate columns to predict over-all two film resistance in other systems are compared and amplified. Predicted efficiencies were compared with actual values in systems involving two-film resistances, as in extractive distillation as presented in a companion paper describing work in which the same plate design was used as in the present study. Bibliography of 8 references.

Minimum Reflux Ratio for Multicomponent Distillation. J. A. May. *Ind. Eng. Chem.*, **41** (1949), pp. 2775-82.

A method is described for the precise calculation of minimum reflux ratio required in multicomponent distillation. The procedure is based upon the resolution of the multicomponent solution into an equivalent series of binary solutions. Within the limitations of assumed constant molal overflow and constant relative volatility, the method is applicable for all feed conditions and can be applied to all types of separations except those involving "split keys," or distributed components. Although somewhat time-consuming for the general case, the method is particularly adaptable to those cases in which the feed is a saturated liquid or a saturated vapor and there are no components present lighter than the light key or heavier than the heavy key. Bibliography of 18 references.

These abstracts from the current literature of science and technology (not including trade journals easily available) were prepared by Drs. Leslie and Coats of The Leslie Laboratories, Traver Road, Ann Arbor, Mich., which will supply, at cost, photostatic copies of original articles. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, also may be had by arrangement with the Laboratories.

Catalytic Butene Isomerization. Chemical Engineering Kinetics of Double Bond Migration. Russell G. Hay, James Coull, and Paul H. Emmett. *Ind. Eng. Chem.*, **41** (1949), pp. 2809-14.

The authors call attention to the need for a method that can be applied to data from a small-scale catalytic reactor to estimate the dimensions of a reactor for a larger unit. The purpose of the work reported was to show that for a reversible reaction of the first order in both directions such an extrapolation, within certain limits, is possible. The double bond migration in n-butene over an alumina catalyst at 482° to 752° F. was studied at butene flow rates of 0.19 to 3.38 pound-moles per square foot of catalyst cross section per hour (space velocities of 400 to 7100 per hour). The data were correlated by plotting the height of a reactor unit versus the butene flow rate at each temperature. The height of the reactor unit is shown by mathematical treatment to be a linear function of the gas flow rate at constant temperature and, for the flow rate range studied, the data verify this conclusion. From a consideration of the Arrhenius equation, it is shown that log H should be approximately a linear function of 1/T for constant gas velocity. This relationship was found experimentally to hold over the temperature range studied. For this reaction the rate-controlling step is the surface reaction, but the theoretical treatment shows that the linear relation between H and the flow rate should hold for any reversible reaction of apparent first order in both directions. Bibliography of 11 references.

Moving Bed Catalytic Cracking Correlations. Product Distribution and Process Variables. J. W. Schall, J. C. Dart, and C. G. Kirkbride. *Chem. Eng. Progress*, **45** (1949), pp. 746-54.

The authors present the results of a pilot plant investigation undertaken to determine the effect of the process variables space rate, catalyst-to-oil ratio and temperature on product distribution and product quality in moving bed catalytic cracking. The data were obtained from once-through cracking of an East Texas heavy gas oil over plant-aged silica-alumina bead catalyst. The purpose of the work was to obtain process

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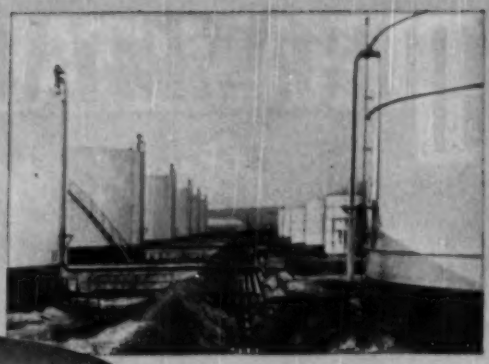

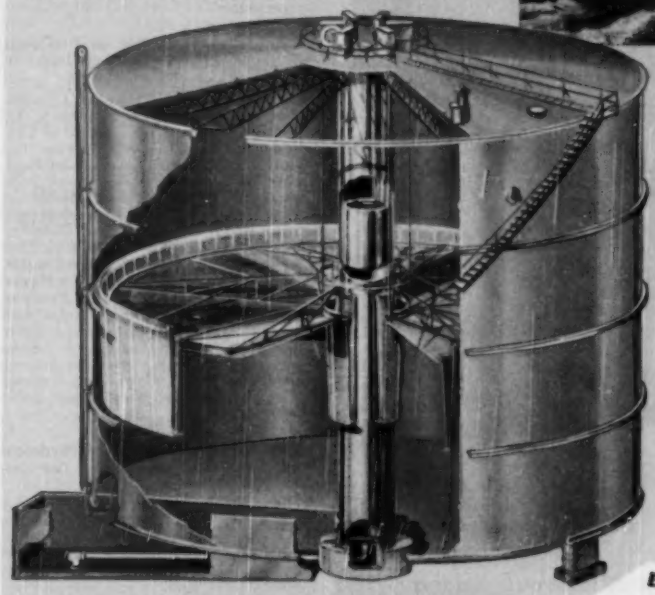

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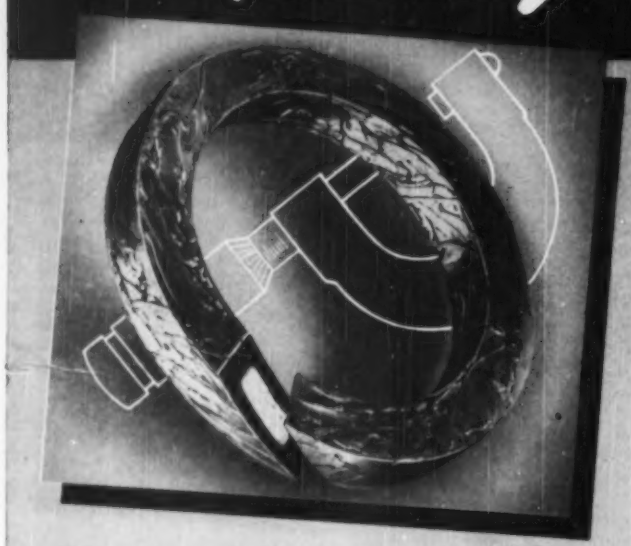

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data for use in design and operation of commercial catalytic cracking units. Correlations developed are presented as a series of charts and the authors state that these derived basic correlations will assist the process engineer in the design of commercial units and also provide a basis for adjusting the operation of commercial units to meet the refiner's requirements. The correlations show that catalyst-to-oil ratio and space rate are interchangeable variables. An infinite number of combinations of catalyst-to-oil ratio and space rate can be used to obtain a particular product distribution at a given temperature.

Symposium on Sulfur in Petroleum. *Ind. Eng. Chem.*, **41** (1949), pp. 2680-2740.

The symposium comprises 11 papers presented at the American Chemical Society meeting in San Francisco. The papers discussed Sulfur Content of Catalytically Cracked Gasolines; Sulfur Distribution in Thermal Cracking of High-Sulfur Feed Stocks; Separation of Sulfur Compounds by Adsorption on Silica Gel; Extraction of Sulfur Compounds with Hydrogen Fluoride; Catalytic Desulfurization of Crude Oil; Desulfurication-Hydrogenation of High-Sulfur Catalytically Cracked Cycle Stock; Hydrodesulfurization of Gasoline Fractions with Tungsten-Nickel Sulfide Catalyst; Stability of Fuel Oils in Storage; Effect of Sulfur on Combustion of Leaded Gasoline; Azeotrope Formation between Thiols and Hydrocarbons; Thermodynamic Properties of Some Sulfur Compounds.

Chlorination of Saturated Hydrocarbons. WILHELM HIRSCHKIND. *Ind. Eng. Chem.*, **41** (1949), pp. 2749-52.

Chlorination of saturated hydrocarbons started in 1929 with the chlorination of pentane. The chlorination of methane and its homologs is more difficult than the chlorination of unsaturated hydrocarbons, such as ethylene and benzene, because the chlorine must be activated either by photochemical or thermal means. Both methods are used commercially, and each has its advantages or disadvantages. Traces of impurities influence the photochemical method by inhibiting the reaction through chain termination. The thermal method requires temperatures of at least 250° C. to start, which, together with a large heat of reaction, demands close temperature control. The author describes a continuous commercial process for the chlorination of methane in which all of the chlorinated methanes are produced. Novel processes for the manufacture of perchloroethylene and hexachloroethane are also described.

Clay Desulfurization of Middle Distillates. W. P. BALLARD, N. A. MERRITT, AND J. C. D. OOSTERHOUT. *Ind. Eng. Chem.*, **41** (1949), pp. 2856-60.

It is necessary to reduce the sulfur content of straight-run middle distillate stock from some West Texas-New Mexico sour crudes. This can be accomplished by conventional acid treating at plants having sulfuric acid recovery plants or other suitable means for disposal of the used acid. The local situation in this regard at some plants is

difficult and the work reported in this paper was done to test the feasibility of clay-desulfurizing these stocks over fuller's earth. A preliminary study of the feasibility of clay-desulfurizing middle distillate stocks indicates that a high-sulfur straight-run middle distillate can be partially desulfurized by vapor phase contact with No. 1 Riverside earth at 750° F. at 1.0 volume per hour per volume space velocity. Degree of desulfurization depends on the proportion of aliphatic sulfur to total sulfur in the stock. By following this treating step with clay vapor treating at the dew point plus rerunning or partial condensation, an oil with a stable color above +12 Saybolt can be made. Lowering the distillation range of the charge stock improves the color and overhead yield. A photograph is given showing lamp chimneys resulting from the charge stock and from stock properly treated. Bibliography of 5 references.

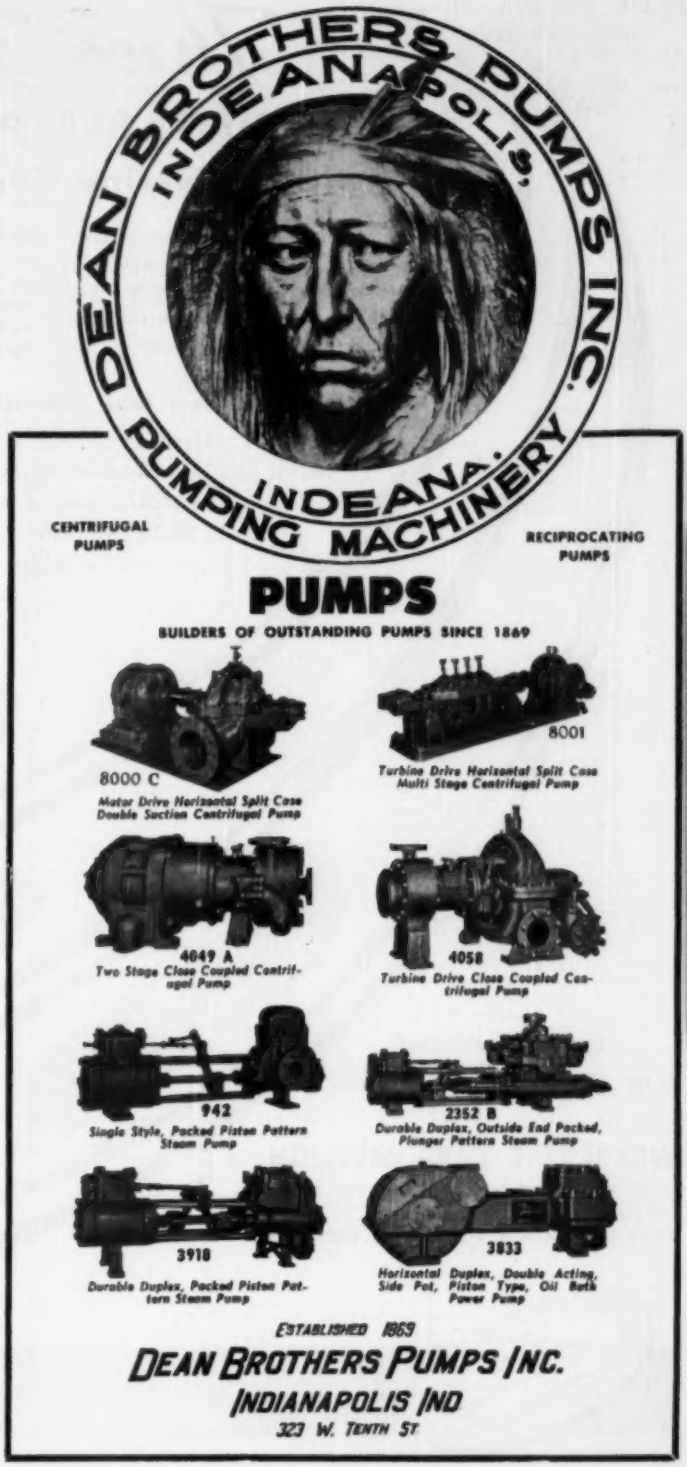
Products: Properties, Utilization and Analysis

Commercial Chemical Development of Butadiene. History and Implications. JAMES H. BOYD. *Ind. Eng. Chem.*, **41** (1949), pp. 2925-8.

This is the third in a series of papers covering the case history of the commercial development of butadiene in the United States. The first paper covered the handling and transportation, and the second, specifications. In the present paper, the author gives the chronology of the development and indicates the limitations as well as the importance of the role played by commercial chemical development. The commercial history of butadiene is first outlined, followed by detailed dates of actual first shipments. Government operations are briefly considered, and, following this, the industrial history of butadiene is given. Production and value of butadiene are given in tabular form, as well as a chronology of synthetic rubber. Bibliography of 24 references.

Spectrophotometric Evaluation of Engine Lubricants. G. L. CLARK, N. H. MUELLER, AND T. W. CULMER. *Analytical Chem.*, **21** (1949), pp. 1485-90.

Wartime investigations showed that the performance of quenching oils for aluminum alloy airplane motor castings could be determined by spectrophotometric curves of the oils that correlated accurately with residual strain in the castings. It was logical to endeavor to extend this optical testing method to engine lubricating oils in the hope of simplifying the standard tests for these oils. In the course of the work, some oils were tested under laboratory conditions using an Underwood tester, and others were tested under actual operating conditions in automobile and diesel engines. Performance of new oils can frequently be predicted from samples prepared by heating the oil in open test tubes in the presence of metal turnings (corresponding to the engine walls). Striking similarity was noted between the graphs of optical data and those for



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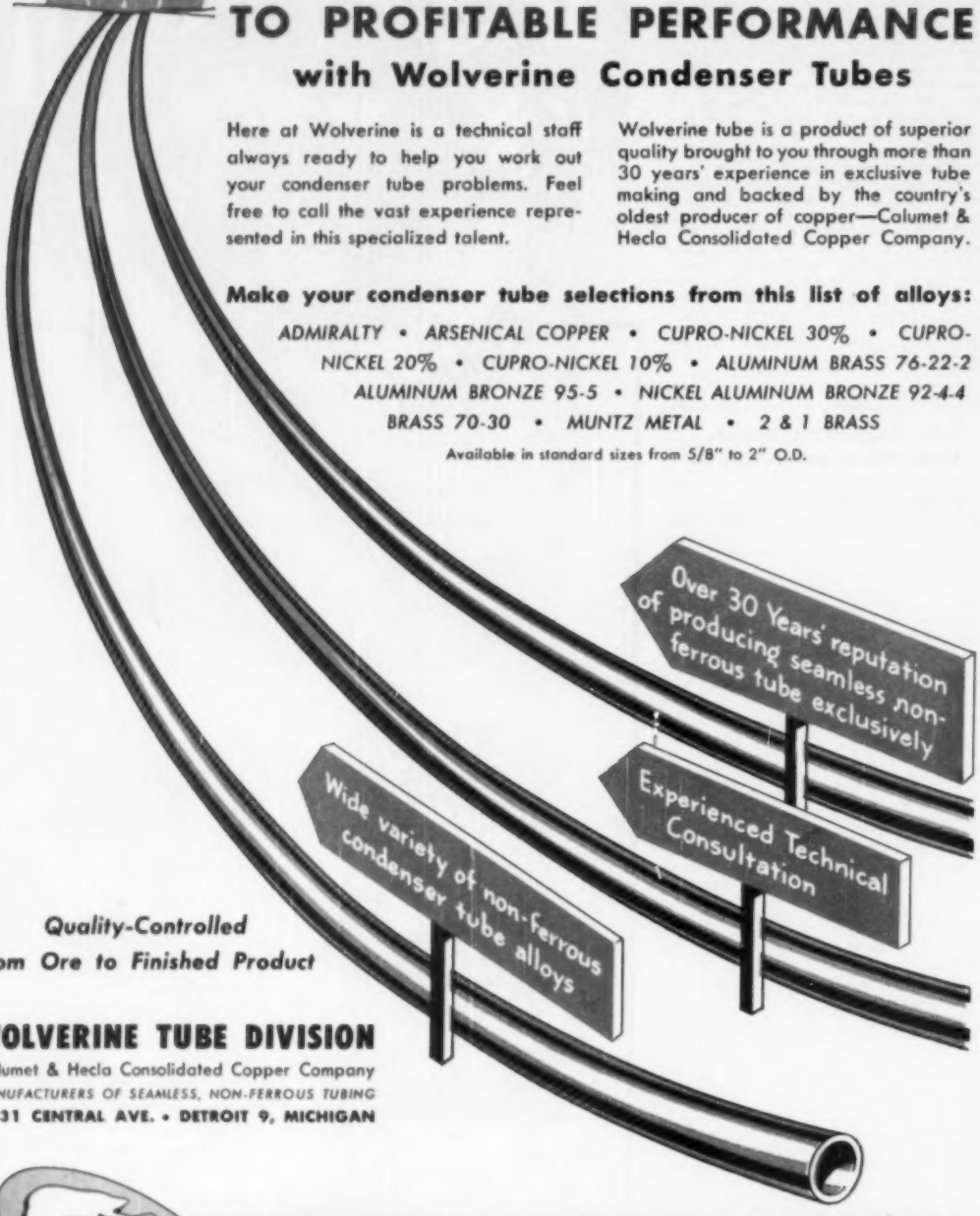
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such tests as percent asphaltenes, carbon residue, neutralization number, viscosity, chloroform-solubles and insolubles, etc. This suggests a definite relationship between the optical properties and chemical and physical data that indicate relative amounts of oxidation, polymerization, and other deterioration with use. Thus the spectrophotometric method indicates a rapid means of rating engine lubricating oils with and in advance of use. Apparently the change in light absorption is an integrative indication of chemical and physical changes, including development of colloidal sludge, that occur under conditions of oxidation and heat in the engine. The indeterminate variables in engine operation, such as contamination by incompletely burned fuel products, carbon deposits, etc., limit application of this or any other method of used oil analysis.

Some Aspects of the Use of Mineral Oils in Baking Practice with Particular Reference to Bread. J. B. M. Coppock and M. A. Cookson. *Jour. Soc. Chem. Ind.*, **68** (1949), pp. 274-7.

Mineral oil used for lubricating or greasing purposes in the baking industry is absorbed in some measure by the baked product. The authors describe an analytical method for the determination of mineral oils in bread. The way in which such oils are contained or bound in the bread is discussed. Possible physiological effect of the oils is considered, as a result of which it is suggested that bread should not contain mineral oil of chemical purity less than that of the pharmacopoeia nor should the quantity of oil exceed 0.2 percent.

Petroleum Control Testing by X-Ray Absorption. Ralph C. Vollmar, Earl E. Petterson, and Paul A. Petruzzelli. *Analytical Chem.*, **21** (1949), pp. 1491-4.

The authors describe the application of X-ray absorption techniques to quality control of petroleum products. Procedures are described for rapid, direct, and nondestructive analytical determinations of sulfur, tetraethyl lead, and metallic additives. The measurements were made by using an X-ray photometer of the type described by Michel and Rich. Petroleum derivatives were used containing small amounts of elements of substantially higher atomic number than carbon. Information is given on the useful range, method of calibration and standardization of test conditions in applying the procedure to petroleum products. The accuracy of the method is comparable to gravimetric or other established procedures. The limitations, including nonspecificity, are considered. Bibliography of 11 references.

Determining the Vapor Pressure of Petroleum Fractions. Arthur C. Santora. *Analytical Chem.*, **21** (1949), pp. 1483-5.

A new apparatus is described for determining the vapor pressure of approximately 5-gram samples of pure or mixed hydrocarbons. The apparatus and its method of construction are given. Calibration, limitations of the method, and theoretical considerations are discussed. The results obtained are reproducible and in close agreement with those as determined by the ASTM Reid vapor pressure method.

High Efficiency Laboratory Fractionation. III. A Small Analytical Still. O. G. Dixon. *Jour. Soc. Chem. Ind.*, **68** (1949), pp. 299-300.

A small still for the fractionation of about 20 ml. of liquid is described. The fractionating column was 6 inches long and ¼-inch bore and was packed with 1/16-inch gauze rings. The column was tested using a mixture of normal heptane-methyl cyclohexane, and was found to have a performance equivalent to about 12 theoretical plates at a vapor velocity of 0.8 foot per second. The dynamic hold-up was 1 ml. and the static hold-up 0.1 ml.

Determination of Acetylene and Monosubstituted Acetylenes. J. Gordon Hanna and Sidney Siggia. *Analytical Chem.*, **21** (1949), pp. 1469-70.

The authors have adapted the qualitative procedure of Shriner and Fuson to the quantitative estimation of acetylene compounds. The procedure involves the use of potassium mercuric iodide and potassium hydroxide to form the mercuric acetylene compound plus potassium iodide. Quantitative estimation is based on determination of the potassium hydroxide consumed. The method can be used for the determination of acetylene or alkyl acetylenes.

Determination of Carbon Monoxide in Hydrocarbon Gases Containing Olefins. Paul R. Thomas, Leon Donn, and Harry Levine. *Analytical Chem.*, **21**, (1949), pp. 1476-80.

Studies of hydrocarbon synthesis and catalytic cracking made it necessary to determine carbon monoxide in gases containing large quantities of olefins. Although numerous methods have been published for the determination of carbon monoxide, they are not applicable when the samples contain olefins. In the procedure described, all hydrocarbons except methane are removed rapidly by condensation in liquid nitrogen, from which the uncondensed gases, carbon monoxide, hydrogen, nitrogen, oxygen and methane are removed by a Töpler pump. The oxygen is then absorbed and carbon monoxide determined. The larger part of the carbon monoxide is absorbed in acid cuprous chloride and the remainder in cuprous sulfate-2-naphthol. Carbon monoxide can be determined in concentrations from 0.1 to 100 percent with an average error of less than 0.5 percent of the carbon monoxide in samples containing 10 percent carbon monoxide. The accuracy is somewhat less for lower concentrations. The determination requires approximately one hour.

Extreme Temperature Lubricating Greases From Silicones and Silicone-Diester Mixtures. R. L. Merker and W. A. Zisman. *Ind. Eng. Chem.*, **41** (1949) pp. 2546-51.

A new and useful class of lubricating greases can be prepared by dispersing lithium stearate in the several types of silicone fluids with the aid of certain volatile mutual solvents. The aliphatic esters of dicarboxylic acids are miscible with some of the silicone fluids and can be used as a mutual solvent. The lithium stearate greases prepared from these silicone-diester mixtures resemble the greases prepared from pure diester fluids and lithium stearate in texture and working properties. Both classes of greases are characterized by good stability with respect to heat, oxidation, and mechanical working. They have low syneresis and evaporation rates and will effectively lubricate ball and roller bearings over the temperature range —60 to 325° F. when the silicones alone are used and from —130 to 250° F. when silicone-diester mixtures are used. Satisfactory methods have been developed for preparing both types of greases by modification of conventional methods. The greases appear to be uniquely suitable for lubrication at elevated temperatures. A bibliography of 18 references is included.

Determination of End Unsaturation in Organic Compounds. Clark E. Bricker and Karl H. Roberts. *Analytical Chem.*, **21** (1949) pp. 1331-4.

The authors describe a chemical method for detecting and determining terminal or end unsaturation in mixtures of unsaturated organic compounds. The material under examination is treated with a slight excess of potassium permanganate in order to form glycols which are then split by means of periodic acid. Formaldehyde is a product of this reaction when terminal double bonds are present an determination of formaldehyde thus affords a specific method for determining end unsaturation. The formaldehyde is separated by distillation and determined spectrophotometrically by means of chromotropic acid. Limitations of the method as regards interferences with the procedure are discussed.

Fundamental Physical and Chemical Data

Phase Equilibria in Hydrocarbon Systems. Phase Behavior in the Methane-n-Butane-Decane System at 160° F. H. H. Reamer, J. M. Fiskin, and B. H. Sage. *Ind. Eng. Chem.*, **41** (1949), pp. 2871-5.

The compositions of the coexisting phases in the methane-n-butane-decane system were investigated at 160° F. Experimental measurements were made at pressures of 1000, 2000, 3000, and 4000 psia. The data permit the evaluation of the composition of the phases and the equilibrium constants in relation to pressure. The results are presented in detail in tabular and graphical form. Although the work covered several temperatures, the measurements obtained at 160° F. have been presented first in order that the details of the analytical procedures and equipment employed might be discussed. Bibliography of 21 references.

Vapor-Liquid Equilibria Data for Ternary Mixtures Methyl Ethyl Ketone-n-Heptane-Toluene System. Harry H. Steinhauser and Robert R. White. *Ind. Eng. Chem.*, **41** (1949), pp. 2912-20.

The development of azeotropic and extractive distillation as an important separation process of chemical industry has stimulated many investigations of the vapor-liquid equilibria of non-ideal systems. Although many data are available, correlations of these data to a generalized and conveniently usable form has proved to be an exceedingly difficult problem. The authors suggest the application of the Gibbs-Duhem equation as a means of evaluating ther-

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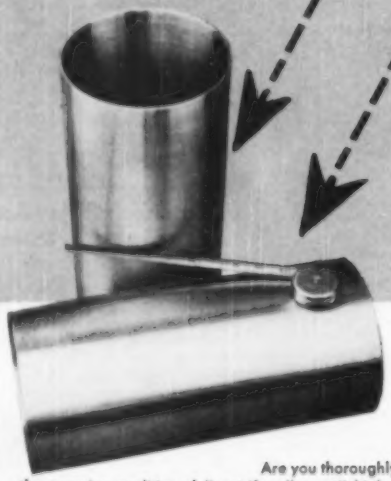

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modynamic consistency. Although this does not constitute proof of equilibrium it does constitute powerful presumptive evidence of equilibrium. Vapor-liquid equilibrium data for the system methyl ethyl ketone-n-heptane-toluene at 1 atmosphere are presented. This system was chosen because of its commercial interest in the preparation of toluene from other hydrocarbons. The data are consistent to ±0.002 mole fraction and ±0.2° C. and appear to be accurate to ±0.004 mole fraction and ±0.2° C. The data are also correlated empirically. Bibliography of 20 references.

Vapor-Liquid Equilibrium Still for Partially Miscible Liquids. THOMAS E. SMITH AND ROBERT F. BONNER. *Ind. Eng. Chem.*, **41** (1949), pp. 2867-71.

Although many types of equilibrium stills have been proposed for use with miscible liquids, few have been thus far described for use with systems of partially miscible liquids. The authors briefly review previously described stills. The apparatus designed by them is stated to be simple to construct and to operate. For this reason it appears well adapted to the procurement of x-y data needed for the design of plant distillation equipment. Vapor-liquid equilibrium data obtained by use of the still for the system 1-butanol-water were found to meet the thermodynamic requirements of the different Gibbs-Duhem equation. The van Laar integrations of this equation, however, were inapplicable. Except at low water concentrations, the data were in general agreement with the values reported by Stockhardt and Hull. Comparative results are shown in graphical form. Bibliography of 12 references.

System Water-Diethylamine-Toluene. Use in Testing Extraction Columns. W. E. WEHN AND N. W. FRANKE. *Ind. Eng. Chem.*, **41** (1949), pp. 2853-5.

The system, water-diethylamine-toluene, is proposed for testing the efficiency of extraction columns because it has solubility relationship and chemical properties that avoid most of the difficulties with systems that have previously been used. Use of this system allows more accurate calculation of the height of the transfer unit or the height equivalent to a theoretical stage than most of the systems for which materials and distribution data are commonly available. The data are given and curves are presented showing the distribution coefficient and the ternary diagram. Distribution data are given for three temperatures, 19.9°, 24.4°, and 29.9° C., and ternary data are given at 24.4° C. To illustrate the use of the data and the procedure results of testing a glass extraction column 6 feet long and 4 inches i.d. packed with 5 feet of 0.5-inch Berl saddles are given. Bibliography of 6 references.

Thermodynamic Properties of Nitroparaffins. D. E. HOLCOMB AND C. L. DORSEY, JR. *Ind. Eng. Chem.*, **41** (1949), pp. 2788-92.

The heats of combustion of 6 mononitroparaffins and 4 polynitroparaffins, including 3 sets of isomers, were determined experimentally with an average precision of approximately 2 parts in 1000. Heats of formation were calcu-

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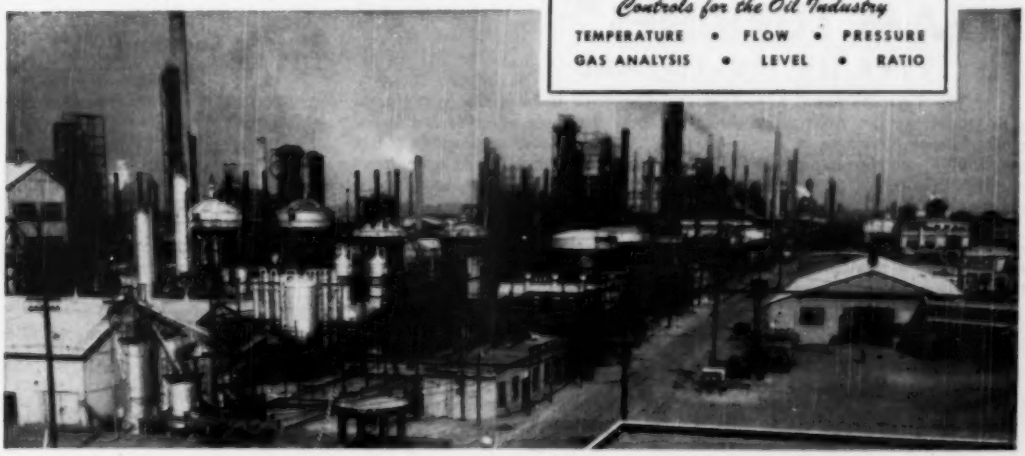

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lated from the experimental heats of combustion. Latent heats of vaporization of 6 mononitroparaffins and one dinitroparaffin were estimated with an approximated error of not greater than 1 percent by using experimental vapor pressure measurements made with precision of approximately 0.2 percent. The heats of combustion of the nitroparaffins have been shown to be a linear function of the oxygen balances of the molecules; an equation was derived and is given that relates these variables with an average error of about 2 percent. Empirical correlations between heats of combustion and chemical structure apply to the nitroparaffins with an average error of about 1 percent. Bibliography of 28 references.

Surface Tensions of Pure Liquids and Liquid Mixtures. H. P. MEISSNER AND A. S. MICHAELS. *Ind. Eng. Chem.*, **41** (1949), pp. 2782-7.

Increasing importance is being attached to the influence of surface tension on efficiency of fractionation, absorption, and extraction processes in various industries, as for example, in the effect on the efficiency of gas-liquid contact in processes such as distillation and absorption. A simple method for predicting surface tension of multicomponent liquids would be useful and a method estimating this property of organic liquids from the refractive index is presented. Empirical relationships are formulated that permit estimation of surface tensions of aqueous solutions with comparable accuracy. Surface tensions of 19 binary solutions of organic liquids tabulated, as are also the surface tensions of solutions of the lower organic acids and alcohols in water. A bibliography of 16 references is given. The authors caution that care should be exercised in applying the relation to mixtures of compounds differing widely in polarity, where adsorption effects may cause abnormally low surface tensions. They recommend that calculated values should be checked occasionally by direct experimental measurement.

Chemical Composition and Reactions

Synthesis of 1,3-Di-t-butylbenzene and 1,3-Di-t-butylcyclohexane. HERMAN PINES, G. J. CZAJKOWSKI AND V. N. IPATIEFF. *Journal of Amer. Chem. Soc.*, **71** (Nov., 1949), pp. 3798-9.

The preparation of *m*-Di-*t*-butylbenzene, which has not heretofore been synthesized, is described. It was prepared by the dehydrogenation of 1,3-di-t-butylcyclohexane, which, in turn, was obtained from 2,4-di-t-butylcyclohexanone by means of dehydration followed by hydrogenation.

Oxidation of Hydrocarbons. The High-Temperature Reaction. M. F. R. MULCAHY. *Trans. Faraday Soc.*, **45** (1949), pp. 537-41.

The rates of oxidation of propane, n-propyl alcohol, n-propyl chloride, and iso-propyl alcohol, and propylene were determined under comparable conditions over a temperature range. In the low-

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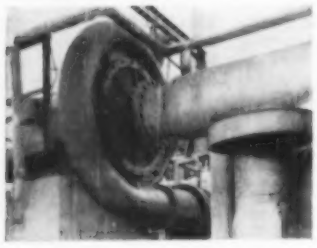

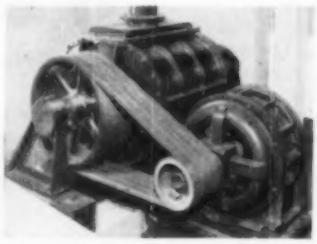

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temperature range up to 300° C. there are differences in reaction rate, which, however, largely disappear in the high temperature range greater than 400° C. A marked structural sensitivity characteristic of the low-temperature oxidation is not noted in the high temperature reaction. In the low-temperature region the structural effect is associated with the nature of the peroxide that takes part in the reaction.

Oxidation of Hydrocarbons. Some Observations on the Induction Period. M. F. R. MULCAHY. *Trans. Faraday Soc.*, **45** (1949), pp. 575-84.

In the low-temperature oxidation of butane, propylene, and isobutane, the reciprocal of the induction period increases linearly with the product of the hydrocarbon and oxygen concentrations. The induction period is defined as the time taken for the reaction to reach the standard rate of pressure increase of 0.5 mm./min. in a silica vessel at constant temperature, into which known pressures of the hydrocarbon and oxygen were admitted. It was noted that the results were more reproducible as the walls of the vessel became coated with a uniform layer of oxidation products.

Polynitro Paraffins. CARL T. BAHNER AND HARVEY T. KITE. *Journal of Amer. Chem. Soc.*, **71** (Nov., 1949), pp. 3597-8.

New polynitro compounds having the nitro groups in the beta position to one another were synthesized by the addition of an alkali salt of a nitro paraffin to a nitro olefin and treatment of the resulting salt with a weak acid. For example, the gradual addition of 2-nitro-1-butene to an alcoholic solution of an equivalent quantity of potassium salt of aci-2-nitropropane gave a 90 percent yield of crude potassium salt of 3,5-dinitro-3-methylhexane. The free dinitro compound was obtained by treatment with acetic acid. Compounds 3,5-dinitroheptane, 3,5-dinitro-3-methylhexane and 1,3-dinitro-2,2-ethyl-3-methylbutane were purified by crystallization from methanol solution at dry-ice temperature.

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Octadecylbenzene
Cyclobutane
2,4-Octadiene
3-Methyl-3-amino-4-heptanol
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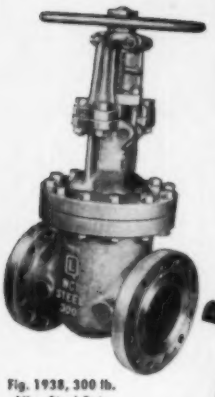

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Fig. 1640, Xing Clip Gate

Fig. 1430, Iron Body Gate

Fig. 400, 400 lb. LP gas

Fig. 16F, Renewa

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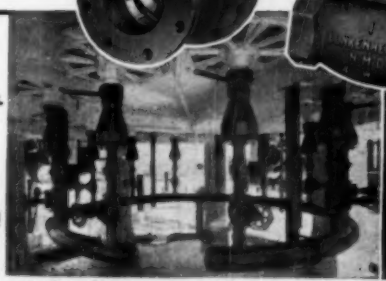
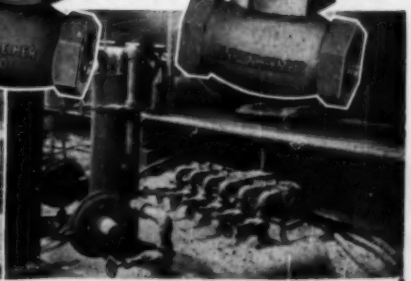
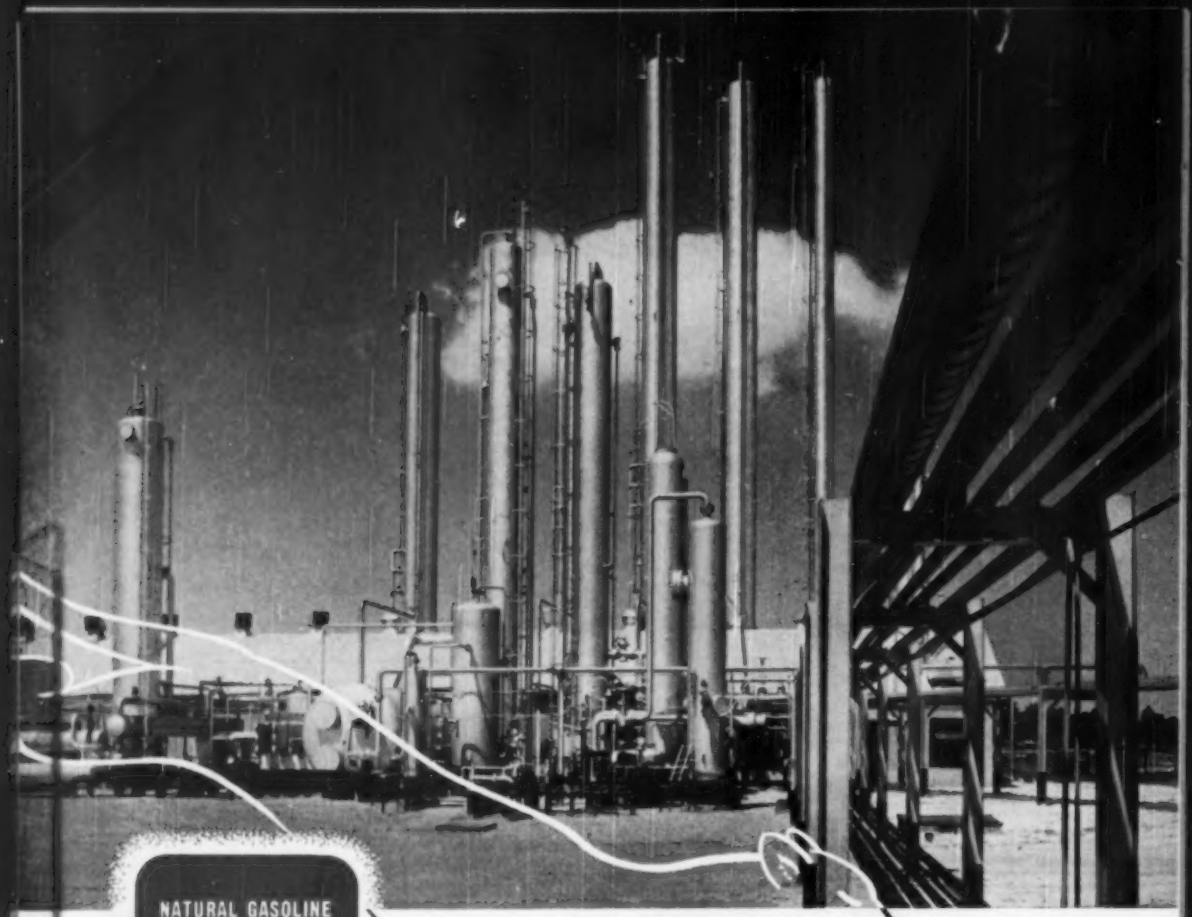


At the refinery . . . Lunkenheimer Bronze Valves control the burners on a petro-chem heater in a Texas gasoline plant.



In the field . . . Lunkenheimer Xing Clip Valves on a fuel manifold to drilling engine on a typical Oklahoma drilling rig.



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Compiled by HEINZ HEINEMANN

(From the Official Gazette, November 15, 22, 29 and December 6, 1949)

REFINING

U.S.P. 2,487,804-5. Selective Sorption Process. D. H. Hermanson to Socony-Vacuum Oil Company, Inc.

The principle of the sorbing method according to U.S.P. 2,487,794 and the same type of sorbent material is employed for separating a liquid mixture of hydrocarbons having components of differing molecular volume. The air contained in the pores of the sorbent are at least partly replaced by a gaseous material which is appreciably soluble in the lower mol. vol. components of the mixture to increase the rate of sorption. The larger mol. vol. components are left substantially unsorbed. U.S.P. 2,487,805 makes use of the method of U.S.P. 2,487,804 for the same purpose but without pretreatment of the sorbent with the gaseous material soluble in the lower mol. vol. components of the mixture.

U.S.P. 2,487,806. Deasphalting Process. D. A. Hermanson and J. L. Biles to Socony-Vacuum Oil Company, Inc.

Asphalt-bearing petroleum stock is deasphalted by a method making use of the sorbent characterized in U.S.P. 2,487,794. The oil-containing sorbent obtained by the treatment is separated from the unabsorbed asphaltic constituents, whereupon the sorbed oily constituents are desorbed.

U.S.P. 2,487,909. Composition for Use as Antioxidant for Motor Fuels. H. Von Bramer to Eastman Kodak Company.

Hydrocarbon motor fuels, particularly those produced in the cracking of petroleum are protected against deterioration on storage by the addition of an antioxidant consisting of N,N'-diisopropyl-p-phenylenediamine and acetone, methyl ethyl ketone, diethyl ketone, or methyl isopropyl ketone. The ketone shall constitute 25-75 percent by weight of the antioxidant.

U.S.P. 2,488,593. Process for Resolving Petroleum Emulsions. J. L. Harlan to Standard Oil Development Company.

Petroleum emulsions of the water-in-oil type are broken by means of a petroleum sulfonic acid body having a nitro group attached to the hydrocarbon nucleus.

U.S.P. 2,489,042. Recovery of Naphthalene and Homologues from Petroleum Products. E. C. Medcalf, H. B. H. Cooper, and W. E. Sisco to American Cyanamid Company.

Aliphatic hydrocarbons containing condensed nuclei aromatics and alicyclics are extracted with iminodipropionitrile at a temperature of at least 100° C. The raffinate and extract layers formed are separated. Alicyclic compounds are recoved from the extract.

U.S.P. 2,489,051. Rocket Propulsion Utilizing Hydrocarbon, Sulfate Turpentine, Nitric Acid, and Sulfuric Acid or Oleum. J. M. Sayward and D. E. Nagy to American Cyanamid Company.

A rocket propulsion fuel comprises a volatile aliphatic hydrocarbon having at least 15-25 percent of a terpene hydrocarbon dissolved therein, together with an oxidant comprising HNO_3 containing 10-30 percent of H_2SO_4 or oleum.

U.S.P. 2,490,606. Fuel Compositions. C. G. Williams and G. H. N. Chamberlain to Shell Development Company.

A fuel composition comprises a gasoline hydrocarbon fraction, tetraethyl lead, and an effective scavenging amount of acetylene tetrabromide. The use of the latter compound instead of other scavenging agents results in a substantial decrease in lead compound deposits on portions of the combustion chambers.

CATALYST PREPARATION, ACTIVATION AND REGENERATION

U.S.P. 2,487,867. Catalyst Purification. L. I. Griffin, Jr., to Standard Oil Development Company.

Oily and waxy deposits are continuously removed from a fluidizable iron or cobalt synthesis catalyst by a method claimed in detail. The contaminated catalyst is continuously removed from the hydrocarbon synthesis reaction zone and subjected in the fluidized state to a destructive hydrogenation reaction of the contaminants. The catalyst thereby freed from volatile hydrogenation products is subjected to extraction with a low-boiling solvent for removing that portion of the hydrogenation products which is nonvolatile under the conditions of the destructive hydrogenation.

U.S.P. 2,488,128. Preparation of Silica Microsphere Supported Iron Group Catalyst. C. N. Kimberlin and R. E. Schexnailder to Standard Oil Development Company.

A fluidizable hydrocarbon synthesis catalyst is formed by suspending a silica hydrosol in a hydrocarbon oil, agitating the susupension until hydrogel microspheres are formed. The hydrogel is separated from the oil and washed with water and then with a low mol. wt. monohydric alcohol. The dried gel is impregnated with an aqueous solution of an iron group metal salt and a solution of a promoter salt. The impregnated gel is heated and treated with a gaseous reducing agent.

U.S.P. 2,488,150. Preparation and Regeneration of a Hydrocarbon Synthesis Catalyst. G. H. Walden, J. A. Pierce, and M. A. Segura to Standard Oil Development Company.

In a Fischer-Tropsch hydrocarbon synthesis by means of a fluidized Fe, Ni, or Co catalyst, carbonized catalyst particles withdrawn from the reaction zone are passed through an oxygen torch flame, then treated in a reducing atmosphere and thereafter returned to the reaction zone. The treatment in the torch flame which may have an effective temperature of above 3000° F. gives catalyst particles of desirable size by sintering.

U.S.P. 2,488,530. Feldspar-Iron-Alkali Fischer-Tropsch Catalyst and Its Preparation. A. H. Friedman and J. N. Moran to Phillips Petroleum Company.

A Fischer-Tropsch synthesis catalyst comprises a reduced particulate fused mixture of iron oxide and a mixed silicate of aluminum and an alkali or alkaline earth metal, wherein the amount of silicate ranges from 20-75 percent. The silicate may consist of feldspar, while magnetite may be employed as the iron oxide material.

U.S.P. 2,488,560. Structure of Contact Masses. O. Reitlinger, Kew Gardens, N. Y.

A contact mass useful as a catalyst for different hydrocarbon conversion reactions consists of a support, a porous surface formed by a plurality of layers of coherent discrete catalyst particles, and associated with the support a bond-

Patents

ing substance containing a hydrophilic metal compound which bonds only the innermost layers of the porous surface to the support.

U.S.P. 2,488,718. Process for the Removal of Catalyst Impurities from Regenerated Catalyst. R. A. Forrester to Standard Oil Development Company.

Spent cracking catalyst is regenerated by hot combustion supporting gases and then contacted with anhydrous HCl and with anhydrous chlorine at a temperature of 850-1200° F. to remove metallic contaminants before re-use of the catalyst.

U.S.P. 2,488,744. Process for the Regeneration of Catalyst. J. A. Snyder to Standard Oil Development Co.

The process of this patent is closely related to that of U.S.P. 2,488,718. In the present case, the regenerated catalyst is contacted with a gaseous mixture of anhydrous HCl and chlorine at the given temperature while in the first case the treatment with chlorine usually follows that with HCl.

U.S.P. 2,489,309. Preparation of an Iron-Freed Acid-Treated Kaolin Catalyst. G. A. Mills and E. B. Cornelius to Houdry Process Corporation.

Adsorbent contact masses are formed from Al-containing clay by treating the finely divided clay with enough acid to dissolve at least a substantial amount of the Al-content. The Al-salts containing extract formed is separated from the clay residue containing undissolved Al-compounds and purified to remove Fe-compounds. The purified extract is recombined with the clay residue to form a slurry. An Al-precipitating agent, e.g. alkali metal silicate, is added to deposit the Al-compound onto the clay residue.

U.S.P. 2,489,332. Preparation of an Iron-Freed Acid-Treated Kaolin Catalyst. H. A. Shabaker to Houdry Process Corporation.

The process according to this patent is similar to that of U. S. patent 2,489,-309. In the present case the clay is first mildly treated with acid, e.g. H_2S, to remove the iron and is then further acid treated to dissolve Al-compounds and to precipitate the Al-compounds in the presence of the clay residue.

U.S.P. 2,489,333. Preparation of a Catalyst Composite of Silica-Alumina Gel on Acid-Treated Clay. H. A. Shabaker and T. H. Milliken Jr., to Houdry Process Corporation.

Clay is mixed, for the production of contact masses, with mineral acid to form a slurry. This slurry which contains dissolved FE and Al salts is subjected to electrolysis to remove iron. The purified suspension is admixed with alkali metal silicate solution to form a silica-alumina reaction product embedding the suspended clay solids. The reaction product is permitted to set to a hydrogel which is then transformed to gel and treated to clean and dry the latter.

U.S.P. 2,489,334. Catalysis. H. A. Shabaker to Houdry Process Corporation.

A catalyst comprising silica and a refractory metal oxide, such as zirconia or alumina, is subjected to an atmosphere of dried hot air at a temperature of 1500-1700° F. for a period, more than five hours, sufficient to increase the apparent density of the dried gel by at least 10 percent. During the treatment no water vapor in excess of 0.1 psi. partial pressures is permitted in the air. The steam stability of the catalyst for hydrocarbon conversions is improved by this treatment.

U.S.P. 2,489,863. Process and Apparatus for Regenerating Catalyst Material. R. R. Collins and S. M. Mercier to The Lummus Company and The Jeffrey Manufacturing, Company, respectively.

Spent catalyst continuously withdrawn from the reaction zone of a continuous hydrocarbon conversion process employing a moving catalyst bed is elevated through the regeneration zone in a series of small masses. A portion of the spent catalyst is continuously released from each mass. The fall of the mass is continuously intercepted at rising horizontal levels, and the intercepted portion as well as the unreleased portion of the spent catalyst is continuously elevated to accomplish a net elevation of the catalyst, the released catalyst forming curtains between the successive ascending small masses. Regenerating gas is passed into contact with these curtains to accomplish regeneration.

U.S.P. 2,489,925. Catalyst Feeder. L. W. Omwake to The Lummus Company.

Details are claimed of a feeder for granular material including a rotor rotating on a horizontal axis and having blades extending radially outward and equally spaced around this axis. The mechanism protects the grains of the material from crushing or abrasion.

U.S.P. 2,490,260. Preparation of Catalytically Inactive Inorganic Oxide Particles. C. H. Ehrhardt to Universal Oil Products Company.

A catalyst diluent is prepared by commingling inorganic oxide particles, e.g. silica spheres, with a solution of an organo-metallic compound containing an alkali metal, e.g. a soap solution, and thereafter calcining the particles to burn off the organic material. The resulting solid product is particularly useful as a diluent in the catalytic conversion of hydrocarbons.

CRACKING AND REFORMING

U.S.P. 2,488,713. Catalytic Cracking of Residual Hydrocarbons. J. Delattre-Seguy to Universal Oil Products Company.

A heavy reflux condensate is cracked in a first zone in the presence of freshly regenerated catalyst with partial carbonization of the catalyst. This catalyst is then contacted in a second zone without regeneration or cooling with residual oil and a light reflux condensate boiling above the gasoline range at cracking conditions. Thereafter the catalyst is regenerated and recycled in hot state to the first cracking zone. The hydrocarbon effluents from both zones are combined and fractionated to obtain

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a light and a heavy reflux condensate boiling above the gasoline range. At least a portion of each of these condensates is recycled to the second and to the first cracking zones, respectively.

U.S.P. 2,489,628. Cracking Process for the Production of Olefins from Hydrocarbons. L. P. Evans to Socony-Vacuum Oil Company, Inc.

Details are claimed of a process for the manufacture of valuable products, particularly of gaseous olefin products, from petroleum mixtures, by contact with refractory granules highly heated by combustion of carbonaceous deposits thereon.

U.S.P. 2,490,287. Upgrading of Naphtha. A. B. Welty, Jr., to Standard Oil Development Company.

Naphthenic naphtha is hydroformed in the presence of a mlybdenum oxide, cobalt oxide-molybdenum oxide, or cobalt molybdate catalyst and added hydrogen at a temperature of 875-920° F. and a pressure of 500-750 psi. for a sufficient period of time to effect substantial dehydrogenation of naphthenes with very limited carbon formation. Free hydrogen is removed from the resulting product, which is subjected to thermal reforming at a temperature of 980-1080° F., a pressure of 500-800 psi., and at a feed rate of 5-15 vols. of oil per vol. of reactor per hour. A high octane naphtha is formed.

POLYMERIZATION AND CONVERSION

U.S.P. 2,487,794-6. Hydrocarbon Conversion Process. L. P. Evans to Socony-Vacuum Oil Company, Inc.

Oily constituents present in liquid hydrocarbon fractions also containing asphalt constituents are sorbed into the pores of a contact material in which less than 30 percent of the total pore volume of the particles is occupied by pores having radii greater than 100 Angstrom units. The contact material bearing the oily constituents is then heated in the absence of the asphalt constituents by passing an oxidizing gas into contact therewith to oxidize a portion of the oily constituents and thereby to release sufficient heat to bring the contact material to a temperature suitable for the conversion of remaining oily constituents. According to U.S.P. 2,487,795 the contact material with the sorbed oily constituents is directly contacted with a hot liquid non-wetting heat exchange fluid, e.g. a molten metal, to effect the desired conversion of the oily constituents. According to U.S.P. 2,487,796, preheated hydrocarbon vapor boiling substantially below the oily constituents is employed for the same purpose.

U.S.P. 2,487,824. Catalytic Conversion **of Hydrocarbons.** G. A. Mills to Houdry Process Corporation.

Hydrocarbons are contacted under catalytic cracking conditions with a catalyst comprising an acid-activated montmorillonite clay of improved thermal stability which is obtained by calcination of the acid-activated clay in absence of water vapor at a temperature above 1000° F. followed by mild acid leaching.

U.S.P. 2,487,961. Catalytic Conversion of Fluid Reactants. C. H. Angell to Universal Oil Products Company.

Details are claimed of a process for the conversion of fluid reactants in contact with a relatively dense mass of subdivided solid contact material with regeneration of the spent dense mass by treatment with oxidizing gases. While a portion of the regenerated mass is returned to the reaction zone, another portion thereof is cooled by indirect heat exchange with H_2O and further treated in mixture with spent contact material from the reaction zone by the superheated steam thus produced.

U.S.P. 2,488,027. Method and Apparatus for Catalytic Conversion. J. M. Page, Jr., to Standard Oil Company (Indiana).

Details are claimed of a method and an apparatus for the catalytic conversion of hydrocarbons with regeneration of the spent catalyst employed in a dense turbulent phase. It is the object of the invention to avoid cooling of catalyst after regeneration and to control the regeneration and reaction temperature.

U.S.P. 2,488,028. Catalytic Conversion Process and Apparatus Therefor. F. W. Scheineman to Standard Oil Company (Indiana).

Details are claimed of a process and apparatus for the conversion of hydrocarbons in the presence of suspended solid catalysts with regeneration of the latter. The dense aerated stream of continually removed spent catalyst is conducted in indirect heat exchange with hot regeneration gases before being contacted with the oxygen-containing gases for regeneration.

U.S.P. 2,488,029. Catalytic Conversion System. F. W. Scheineman to Standard Oil Company (Indiana).

Hydrocarbon is passed for conversion upwardly through a first zone containing powdered catalyst at such a rate as to produce a dense, turbulent suspended catalyst phase and a light upper dispersed catalyst phase. Regeneration gases are passed upwardly through a second zone containing powdered catalyst in a corresponding manner. Catalyst withdrawn from the first dense phase is stripped and then introduced into the second dense phase, while regenerated catalyst from this latter phase is reintroduced to the first dense phase. Catalyst from the light upper phases of each zone is separated and returned to the system.

U.S.P. 2,488,030. Fluidized Catalytic Conversion Process. F. W. Scheineman to Standard Oil Company (Indiana).

Details are claimed of a method of effecting catalytic conversion and catalyst regeneration, employing small particle size catalytic solids. The method makes it possible to eliminate to a large extent the contactors, separators, and feeders and thereby to reduce the energy required for the transfer of catalyst from zone to zone. The pressure at the base of a contacting chamber is utilized for injecting catalyst material in a gas or vapor stream entering an upper or intermediate point in another contacting chamber.

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U.S.P. 2,488,031. Catalytic Conversion System. R. C. Gunness to Standard Oil Company (Indiana).

Conversion of hydrocarbon vapors and regeneration of catalyst employed and regenerated in dense turbulent suspended phases are controlled by regulating the level of the catalyst phase in the conversion zone by the removal of catalyst from this zone and by regulating the catalyst-to-oil ratio to control catalyst residence time in the reactor. The level in the regeneration zone is regulated by controlling the amount of new catalyst added to the system.

U.S.P. 2,488,032. Catalytic Conversion of Hydrocarbons and Apparatus Therefor. E. A. Johnson to Standard Oil Company (Indiana).

Details of a method and an apparatus for the conversion of hydrocarbons are claimed. The method allows obtaining and maintaining desired catalyst-to-oil ratios, space velocities, catalyst residence times, and vapor contact times in the reaction zone.

U.S.P. 2,488,033. Catalytic Conversion System. E. A. Johnson to Standard Oil Company (Indiana).

Details of a catalytic hydrocarbon conversion system are claimed which allow a more compact arrangement of reactor and regenerator, so that they can even be combined in a single unit, and the height of the superstructure can be substantially decreased.

U.S.P. 2,488,083. Manufacture of Liquid Hydrocarbons. M. H. Gorin and E. Gorin to Socony-Vacuum Oil Company, Inc.

An alkyl chloride obtained from gaseous hydrocarbons, particularly methane, is passed at 250-500° C. in contact with a catalyst consisting of silica associated with an oxide of Al, Zn, Be, Ga, Mg, Zr, or Th. At least a part of the gaseous olefins and isobutane thus formed in addition to gaseous normal paraffins is recycled from the product effluent to the reaction zone along with a sufficient amount of the gaseous paraffins to maintain in the total feed to the reaction zone a special mol ratio of hydrocarbons to total alkyl chlorides. Normally liquid hydrocarbons are recovered.

U.S.P. 2,488,149. Emulsion Polymerization of Diolefins in the Presence of an Alkyl Ethanolamine Soap. B. M. Vanderbilt and F. Bascom to Standard Oil Development Company.

In the emulsion copolymerization of conjugated diolefins with 4-6 C atoms and a styrene or an acronitrile, the emulsifier consists of a soap-forming acid with 12-18 C atoms neutralized with 50-70 percent of a mol. equivalent of diethyl ethanolamine or another substituted diethanolamine.

U.S.P. 2,488,488. Method and Apparatus for Conversion of Fluid Hydrocarbons. E. V. Bergstrom to Socony-Vacuum Oil Company, Inc.

Details are claimed of a method for the conversion of high boiling liquid or mixed phase hydrocarbons to lower boil-

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ing hydrocarbons in the presence of a moving column of particle-form contact material. The new method is particularly concerned with the supplying of contact material and fluid hydrocarbons onto the contact material column in the conversion zone.

U.S.P. 2,488,493. Apparatus for Conducting Gas-Solid Contact Operations. L. P. Evans to Socony-Vacuum Oil Company, Inc.

An apparatus is claimed for the conversion of hydrocarbon vapors in the presence of a particle form solid contact material. The apparatus takes advantage of the relatively high permissible gas throughput rates obtainable by passage of reactant gases in parallel through a number of superposed reaction zones. Uniformity of the solid material contacting efficiency is maintained in the various levels of the apparatus.

U.S.P. 2,488,502-3. Styrene Emulsion Polymerization Process. H. F. Park, C. H. Basdekis, and R. I. Dunlap, Jr., to Monsanto Chemical Company.

Styrene is emulsion polymerized in the presence of specified parts of potassium persulfate, a sodium salt of mahogany acids, sodium bicarbonate, and dodecyl mercaptan in a particular process claimed in detail. According to U.S.P. 2,488,503, the mahogany acid salt is replaced by sodium stearate.

U.S.P. 2,488,690. Diazoaminobenzene-Phenolic Compound Catalyst Combinations in Butadienec-Styrene Emulsion Polymerization. W. N. Stoops to Carbide and Carbon Chemicals Corporation.

Styrene or conjugated diolefins or mixtures thereof are emulsion polymerized in the presence of a small amount of a catalyst composed of diazoaminobenzene mixed with an activating compound of hydroquinone, monochlorohydroquinone, p-quinone, pyrogallol, quinhydrone, dichlorohydroquinone, or catechol. This type of catalyst effects polymerization several times faster than a peroxidic catalyst.

U.S.P. 2,488,736. Polymerization of Olefins with Friedel-Crafts Catalysts Dissolved in Water Containing Alkyl Halide Solvents. F. A. Palmer to Standard Oil Development Company.

For activating a solution of a Friedel-Crafts catalyst in an alkyl halide, a first stream of alkyl halide is divided into second and third streams. The second stream is saturated with water and then contacted with a Friedel-Crafts catalyst to form a first catalyst solution. This solution is admixed with the third alkyl halide stream to form a second catalyst solution which has enhanced activity. Mono- and di-olefins can be polymerized to high mol. wt. rubbery products by this activated catalyst at temperatures of —50° to —175° F.

U.S.P. 2,488,752. Process for Conversion of Olefins Using the Reaction Product of Oxygen, Boron Trifluoride, and a Hydrocarbon as Catalyst. R. C. Wackher and C. B. Linn to Universal Oil Products Company.

Olefin is contacted at conversion conditions with a catalyst comprising a solid oxygen-containing complex formed by heating oxygen, BF_3, and a hydrocarbon such as a paraffin, e.g. pentane, at a temperature above 150° C. The catalyst is useful in the polymerization of olefins as well as in the alkylation by olefins of aromatic and heterocyclic compounds, etc.

U.S.P. 2,489,226. Method of Making Pigmented Polystyrene. E. D. Morris and S. S. Drake to The Dow Chemical Company.

A liquid consisting of styrene, or solutions of polystyrene in styrene, is incorporated with polystyrene and a pigment dispersed therein, stable to decomposition at temperatures up to 200° C. and insoluble in styrene. A liquid composition is formed which contains an amount of polystyrene sufficient to give the composition a viscosity greater than 60 centipoises at 25° C. This composition is subjected to conditions suitable to polymerize the styrene to a solid.

U.S.P. 2,489,959. Process for Neutralizing Peroxide Catalyst in Styrene Emulsion Polymerization. R. I. Dunlap to Monsanto Chemical Company.

One hundred parts of styrene are emulsion polymerized in contact with 0.05-1 part of an ionizable emulsifier operable at a pH less than 7, and 0.005-0.4 part of ammonium persulfate. One and three-tenths to 2 mols of $Ba(OH)_2$, $Sr(OH)_2$, or $Ca(OH)_2$, or their hydrates per mol of the persulfate are added to the emulsion to neutralize the catalyst and its decomposition products.

U.S.P. 2,490,336. Method for Conversion of Petroleum Hydrocarbons. J. A. Crowley Jr., to Socony-Vacuum Oil Company, Inc.

In the conversion of hydrocarbons, a stream of fresh contact material is introduced under conversion conditions into one end of an elongated conversion zone where it is contacted with fluid hydrocarbons to be converted. Gaseous conversion products are withdrawn. At least one other stream of fresh contact material is introduced into this zone at a temperature substantially higher than the introduction temperature of the first stream, at least one location intermediate its ends, to mix with the first stream and upwardly adjust its temperature sufficiently to supply at least a major portion of the heat absorbed by the conversion reaction.

U.S.P. 2,490,372. Methods of Preparing Polymeric Materials from Isopropenyl Toluene. A. S. Nyquist and E. L. Kropa to American Cyanamid Company.

An isopropenyl toluene containing material is polymerized at a temperature of —80° to +110° C. with the aid of a catalyst which is a seed obtained by treating an isopropenyl toluene with BF_3 or a complex thereof.

U.S.P. 2,490,578. Hydrocarbon Conversion Process. D. R. Carmody to Socony-Vacuum Oil Company, Inc.

Olefins are polymerized by contacting them with a metal halide catalyst solution at a temperature below 0° C. in a first reaction zone to produce a viscous polymer product. Catalyst-hydrocarbon complex is removed from the reaction effluent and the latter is contacted at higher temperature with more olefin in a second zone to produce a polymer having a 210° F. viscosity not greater than 125 Saybolt seconds and at least 500 Saybolt seconds less than the viscosity of the first product. The second polymer product is fractionated into a high and a low viscosity fraction. Complex recovered from the first and the second reaction zones is contacted in a third zone with more olefin at a temperature above 0° C. to produce further polymer product. Maximum yields of both low and high viscosity olefin polymers are obtained with complete utilization of the dissolved catalyst which can be recovered.

U.S.P. 2,490,712. Process for the Polymerization of Diolefin Hydrocarbons. W. A. Schulze and W. W. Crouch to Phillips Petroleum Company.

In the emulsion copolymerization of butadiene and styrene in the presence of a catalyst and a soap emulsifier an aliphatic monohydric saturated alcohol with 5-7 C atoms is added in an amount of 0.5-10 parts per 100 parts of monomeric material. The rate of reaction is materially increased by the additive.

U.S.P. 2,490,713. Controlling Polymer Properties in Emulsion Polymerization by Controlling Intensity of Agitation. W. A. Schulze to Phillips Petroleum Company.

The process according to this patent is somewhat related to that of U.S.P. 2,490,712. The emulsion polymerization, such as that of butadiene-1,3 alone and that of other mixtures of 1,3-diolefins and $CH_2=C<$ compounds, is here carried out in the presence in an amount of 0.36-1 part per 100 parts of the monomer of a tert. alkyl mercaptan with 16 C atoms. While the polymerization mixture is initially agitated only sufficiently to effect minimum emulsification of the entire system, agitation is at least doubled during the reaction period.

ALKYLATION

U.S.P. 2,488,190. Alkylation Process. H. J. Hepp to Phillips Petroleum Company.

Details are claimed of a process for the alkylation of low-boiling olefin with an alkylatable hydrocarbon. An olefin-containing mixture is treated in an absorption zone in admixture with a hydrogen halide with an absorption liquid comprising a liquid aluminum halide-hydrocarbon complex. The resulting olefin-rich absorption liquid is passed to the alkylation zone for further treatment.

U.S.P. 2,488,602. C_4 Alkylation with Aluminum Chloride - Hydrocarbon Complex Catalyst. E. F. Pevere to The Texas Company.

Isobutane is alkylated with butylene in the liquid phase in the presence of a liquid $AlCl_3$-hydrocarbon complex catalyst and a HCl promoter by a special process claimed in detail.

U.S.P. 2,488,603. Propylene Alkylation with Aluminum Chloride Complex

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Catalyst. E. F. Pevere to The Texas Company.

A process similar to that of U.S.P. 2,488,602 is employed for the continuous alkylation of isobutane with propylene.

U.S.P. 2,488,943. Method of Maintaining Acid Catalyst Concentration in an Alkylation Process. A. P. Shearer to Anglo-Iranian Oil Company, Ltd.

Details are claimed of a process for the alkylation of hydrocarbons in the presence of a liquid acid catalyst. The process makes it possible to carry out the alkylation by means of an acid of higher average concentration than usual, without sacrifice in over-all yield and with no increase in acid consumption.

ISOMERIZATION

U.S.P. 2,487,978. Catalytic Isomerization of Olefinic Hydrocarbons. M. J. Murray to Universal Oil Products Company.

Thermally cracked gasoline is contacted at isomerizing conditions with a catalyst consisting of alumina impregnated with an alkaline earth metal halide. The resulting isomerized product has increased octane rating.

U.S.P. 2,489,975. Process of Isomerization in the Presence of a Double Fluoride Catalyst. H. J. Passino to The M. W. Kellogg Company.

An isomerizable hydrocarbon is isomerized under suitable conditions of temperature, pressure, and space velocity in the presence of a catalytic compound of HF and an alkali metal, alkaline earth metal, or ammonium fluoride.

DESULFURIZATION

U.S.P. 2,488,000. Methods of Oxidizing Acidic Sulfur Compounds. G. G. Bernard to The Pure Oil Company.

Petroleum hydrocarbons containing mercaptans are contacted with an oxygen-containing gas in the presence of an alkali metal alcoholate solution containing a small proportion of a phenolic material capable of forming a quinone, such as pyrogallol. The mercaptans are oxidized and thereby removed.

U.S.P. 2,488,855. Sweetening and Desulfurizing Hydrocarbons. J. O. Denton Jr.

A hydrocarbon distillate free of H_2S, but containing other sulfur compounds, is passed through a bed of an adsorbent earth and then mixed with a sufficient amount of alkaline sodium hypochlorite solution to react with 30-40 percent of the sulfur contained therein. After removal of the spent solution, the distillate is washed with a strong alkali metal hydroxide solution and passed through an adsorbent clay.

U.S.P. 2,488,895. Method of Sulfur Re-

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moval from Benzol. A. R. Bayer and E. J. Murphy.

Vapors of crude benzol containing CS_2 are treated with anhydrous ammonia at a temperature of 300-400° F. The treated vapors are condensed, and the condensate is held for a period of time to promote substantial conversion of the S-containing products into products soluble in aqueous alkali, which products are thus removed.

HEAVY OILS AND WAXES

U.S.P. 2,487,840. Lubricating Composition. P. R. Van Ess to Shell Development Company.

A lubricating composition comprises a major amount of a mineral lubricating oil and a minor amount of a stable, sulfur-containing reaction product obtained by reacting a cyclic ketone fraction having at least 12 C atoms with a phosphorus-free sulfurizing agent. The composition obtained is stabilized against deterioration and has improved anti-wear properties.

U.S.P. 2,488,293. Heavy-Duty Industrial Grease. A. J. Hoiberg to Lion Oil Company.

An asphaltic product of a softening point 230-350° F. and PTS of 0.005-0.015 obtained by air-blowing a base petroleum residue in the presence of a catalyst which acts to lower the penetration - temperature susceptibility is blended with 15-70 percent of a petroleum fraction having at least the boiling point of gas oil. A lubricating grease is obtained.

U.S.P. 2,488,618. Lubricants of the Extreme Pressure Type. E. B. Cyphers and G. M. McNulty to Standard Oil Development Company.

A composition consists of 80-99.5 percent of petroleum lubricating oil and 20-0.5 percent of the P-containing reaction product of a phosphorus sulfide with a methyl ester of abietic acid or sulfurized abietic acid and prepared in a special manner. The composition is particularly suited for use as an extreme pressure type lubricant.

U.S.P. 2,489,249. Lubricant. D. E. Adelson to Shell Development Company.

Mineral lubricating oil is compounded with a minor amount of a reaction product obtained from an organic compound, e.g. a high mol. wt. hydrocarbon and H_2S and treatment of the resulting product with phosphorus sulfide, sulfur halide, elemental sulfur, or alkali polysulfide at increased temperature. The additive stabilizes the oil against oxidation and corrosion deterioration.

U.S.P. 2,489,281. Methacrylates in Constant Viscosity Oils. E. G. Foehr to California Research Corporation.

A lubricating mineral oil with superior viscosity-temperature characteristics contains certain amounts of a high mol. wt. oil-soluble polymer of alkyl acrylates or their homologues with at least 4 C atoms in the alkyl group, and certain amounts of an oil-soluble Al- or Mg-soap.

U.S.P. 2,489,300. Lubricants and the Like. F. A. Leyda to California Research Corporation.

A lubricant of superior viscosity-temperature characteristics consists of 85-99 percent by weight of a petroleum lubricating oil, 0.5-6 percent of a cellulose ether insoluble in the petroleum oil at normal temperature, and 0.5-6 percent of an Al- or Mg-soap as disperging agent.

U.S.P. 2,489,301. Lubricating Oils and the Like. E. G. Foehr and F. A. Leyda to California Research Corporation.

In 65-94 percent by weight of a hydrocarbon lubricating oil, 0.5-6 percent of a high mol. wt. thermoplastic material is dispersed which has recurring oxygen-containing polar groups. Five-tenths to six percent of a polyvalent metal soap as disperging agent and 5-20 percent of an oxygen-containing polar solvent solubilizing agent for the polymeric material are added.

U.S.P. 2,489,671. Oil Compositions. A. J. Revukas to Tide Water Associated Oil Company.

In a mineral oil is dissolved a polymerized ester of the formula $CH_2=CX-COOR$, wherein X is hydrogen or the methyl group and R is a hydrocarbon group of 4-18 C atoms, and 0.01-1 percent of a water-insoluble trialkyl amine or an oil-soluble amine of the formula $A-CH_2-N<^{R^1}_{R^2}$ wherein R^1 and R^2 are alkyl radicals containing a sum of more than 6 C atoms and A is a phenol having at least one nuclear hydrogen atom replaced by a hydrocarbon group. The first named additive improves the viscosity index of the resulting lubricant but has a tendency to cause emulsification. This tendency is reduced by the second additive.

U.S.P. 2,490,068. Lubricants. B. H. Lincoln and J. M. Hersh to Continental Oil Company.

Hydrocarbon lubricating oil contains 0.0001-10 percent of a di-ester of azelaic acid, the terminal carboxyl groups of which are substituted with at least one diphenyl silicon-containing group.

U.S.P. 2,490,264. Rust Preventing Composition. J. D. Garber to Standard Oil Development Company.

A rust preventing composition consists of 80-98 parts of mineral oil, 0.1-10 parts of a petroleum metal sulfonate, and 0.5-15 parts of a copolymer of butadiene and diisobutylene with a mol. wt. of 1,000-15,000.

PETROCHEMICALS

U.S.P. 2,486,657. Diolefin Phosphonic Acids and Polymers Thereof. G. M. Kosolapoff to Monsanto Chemical Company.

Butadiene or isoprene is mixed with PCl_3 at a temperature below 20° C. The corresponding chloroalkene phosphorus tetrachloride is formed. This product is mixed with water or an aliphatic alcohol in the presence of an alkaline material whereby it is hydrol-

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ized and dehydrochlorinated with formation of the butadiene or isoprene phosphonic acid.

U.S.P. 2,486,659. Catalytic Process for the Preparation of Acrylic Acid Nitrile. P. Kurtz to the Attorney General of the U. S.

Acetylene and HCN are contacted with an aqueous acid reacting solution of Cu_2Cl_2 which also contains a salt of ammonium, amine or alkali metal. Acrylic acid nitrile is produced.

U.S.P. 2,486,454. Polybasic Acids and Methods for Producing Same. C. N. Zellner to The Tide Water Associated Oil Company.

Predominantly paraffinic hydrocarbons are partly oxidized in liquid phase by contacting them at a temperature of 120-180° C. with an oxygen-containing gas. The rate of feed of the gas to the hydrocarbons and the gas distribution are controlled so that there is maintained dispersed in the hydrocarbons an amount of gas sufficient to cause combination of the oxygen at a specific average rate. Important amounts of polycarboxylic acids are formed.

U.S.P. 2,487,777. Manufacture of 1-Naphthyl Methyl Ketone. C. Baddeley to Imperial Chemical Industries, Ltd.

A complex compound obtained from a Friedel-Crafts catalyst with acetyl chloride or acetic anhydride is reacted with naphthalene and a chloro- or bromoparaffin solvent, such as ethylene dichloride. 1-Naphthyl methyl ketone is produced.

U.S.P. 2,487,820. Fluorination of Fused-ring Hydrocarbons with Lead Tetrafluoride. E. T. McBee and R. M. Robb to Purdue Research Foundation.

Fused-ring hydrocarbons, such as naphthalene or anthracene, are vaporized and then reacted with solid lead tetrafluoride at a temperature above the b.p. of the hydrocarbon and below 500° C. The resulting product has the carbon structure of the charge hydrocarbon wherein hydrogen is replaced with fluorine and at least one double bond present in the feed hydrocarbon has been saturated with fluorine.

U.S.P. 2,487,986. Reaction of Bicyclo-Olefins with Alkyl Halides. L. Schmerling to Universal Oil Products Company.

Bicyclo-(2,2,1)-heptene-2, as obtained by reacting ethylene with cyclopentadiene or dicyclopentadiene, is reacted in the presence of a Friedel-Crafts halide catalyst with a tert. alkyl halide, preferably a chloride or bromide. A halobicycloheptane is produced.

U.S.P. 2,488,082. Manufacture of Acetylenic Alcohols. E. G. Galitzenstein and C. Woolf to The Distillers Company, Ltd.

An acetylene feed is passed at a temperature of −15° to +10° C. to an anhydrous dispersion in an inert organic diluent of an alkali metal alcoholate of a primary or secondary saturated alcohol sparingly soluble in water and containing only one hydroxyl group. A ketone is added to the reaction mixture formed, and a second acetylene feed is added to the thus obtained mixture. Acetylenic alcohol is obtained. The alkali metal alcoholate is regenerated.

U.S.P. 2,488,721. Sulfonic Acid Manufacture. G. R. Gilbert to Standard Oil Development Company.

A substantially aromatic petroleum lubricating oil fraction is contacted at a temperature of 130-160° F. with an acid sludge separated from such a lubricating oil fraction after its treatment with H_2SO_4 of at least 98 percent strength, fuming sulfuric acid, SO_3, chlorsulfonic acid, or fluorsulfonic acid. Mahogany sulfonic acids are produced.

U.S.P. 2,489,215. Separation of Diphenylbenzene Isomers by Distillation and Crystallization. R. L. Jenkins to Monsanto Chemical Company.

In the separation of the isomers of diphenylbenzene contained in the high boiling residue obtained in the pyrolytic diphenyl synthesis from benzol, a mixture containing substantially only meta- and para-diphelynbenzene is treated for their separation with atmospheric steam while centrifuging the mixture.

U.S.P. 2,489,346. Oxidation Process. A. B. Welty Jr., and W. F. Rollman to Standard Oil Development Company.

Vaporized aromatic hydrocarbons are passed for a period of 0.1-1.0 second together with an oxygen-containing gas and steam upwardly through a bed of coarsely powdered oxidation catalyst at

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such a velocity as to maintain the catalyst particles in motion within the bed. Phthalic anhydride is produced.

U.S.P. 2,489,347. Process for Oxidation of Aromatic Hydrocarbons. W. F. Rollman to Standard Oil Development Company.

The process according to this patent is related to that of U.S.P. 2,489,346. The aromatic hydrocarbon vapor together with oxygen-containing gas is passed upwardly through a mass of spherical particles of vanadium oxide catalyst of 20-40 mesh arranged in the lower portion of a vertical reaction tube at a velocity such that the particles are maintained in motion without being entrained.

U.S.P. 2,490,276. Preparation of Triptane Structure Compounds. J. C. Munday and A. H. Matuszak to Standard Oil Development Company.

2,3-Dimethyl butene is reacted with formaldehyde in the presence of an acidic condensation catalyst, e.g. H_2SO_4. Addition of the formaldehyde to the olefin double bond is effected with formation of products of triptane structure, particularly 2,3,3-trimethyl 4-ol butene-1.

HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,488,145. Hydrogenation of Olefin Polymer Liquids. W. H. Smith and R. B. Mason to Standard Oil Development Company.

A branched olefin polymer oil boiling in the range of 300-500° F. is contacted while at least partly in liquid phase in a hydrogen stream at 400-500° F. with a sulfur-resistant catalyst which is saturated with H_2S adsorbed at 600-900° F. A small amount of H_2S is continuously supplied to the hydrogen stream. Hydrogenated liquid formed is separated from a vaporized portion of the feed oil which is condensed and recycled.

U.S.P. 2,488,406. Method and Apparatus for Conducting Chemical Reactions. J. H. Hirsch to Gulf Research and Development Company.

A Fischer-Tropsch hydrocarbon synthesis employing a finely divided fluidized catalyst is carried out in a closed compartment containing an upper reaction zone; an intermediate cooling zone; a lower mixing zone; a catalyst reactivation zone disposed centrally of, surrounded by, and communicating with the reaction zone; and a conduit zone leading from the reactivation zone to the mixing zone and passing centrally through the cooling zone. The fluidized synthesis catalyst is continuously passed from the reaction to the reactivation zone where high mol. wt. reaction products are removed from the catalyst by means of a hydrogen-rich gas. The still fluidized catalyst is passed from the reactivation zone downwardly through the conduit zone to the mixing zone where a dilute mixture thereof with synthesis gas is formed which is passed upwardly through the cooling zone in a plurality of confined streams to the bottom of the reaction zone.

U.S.P. 2,490,283. Addition of Carbon Monoxide-Hydrogen to Unsaturated Compounds. R. N. Shiras to Shell Development Company.

A synthesis gas with a ratio of H_2:CO = 1.5:1 is contacted with a liquid unsaturated reactant, such as an olefinic petroleum fraction, under absorption conditions. The rich liquid formed is passed to a first catalytic synthesis step where a liquid intermediate product is formed, which is passed to a second synthesis step together with the lean gas from the absorption step. Oxygenated addition products of the unsaturated compounds used are obtained.

U.S.P. 2,490,463. Synthesis of Hydrocarbons. G. G. Oberfell to Phillips Petroleum Company.

A synthesis gas with a H_2:CO ratio between 3:1 and 1:1 is passed over a fixed bed synthesis catalyst at a pressure of 15-500 psi., a temperature of 150-400° C., and a space velocity of 100-400. Liquid mercury is introduced into the reaction zone at a temperature substantially lower than the temperature in this zone in an amount sufficient to maintain the temperature of this zone substantially constant. The mercury is allowed to gravitate through the reaction zone in direct contact with the catalyst, is withdrawn from the lower portion of this zone, and recycled after cooling.

U.S.P. 2,490,488. Hydrocarbon Synthesis Catalyst. S. G. Stewart to Phillips Petroleum Company.

Carbon oxides are hydrogenated by means of a catalyst comprising a major proportion of MoS_2 promoted with a minor proportion of an alkaline compound of an alkali metal. Normally liquid hydrocarbons and oxygenated compounds are thus obtained from carbon monoxide.

Bring on chemicals with TEETH!

"Karbate" Impervious Graphite tube-bundle heat exchanger, floating-end diaphragm construction, used for partial concentration of H_2SO_4 contaminated with volatile organics. Contains 233 tubes, ⅞ in. dia. by 9 feet long. Tube sheets are 28¾ in. dia. by 6¼ in. thick.

"KARBATE"

Impervious Graphite Heat Exchangers ARE READY!

"Karbate" Impervious Graphite Heat Exchangers handle an extremely wide range of corrosive fluids. They are both acid-resistant and alkali-resistant. Their thermal conductivity is higher than that of most commonly used metals. They are light in weight, immune to thermal shock, will not contaminate the solution, and are amply strong and vibration resistant. "Karbate" heat-exchanger types include: tube-bundle, cascade, plate, bayonet, and concentric in standard and special sizes.

Other "Karbate" equipment includes: pipes and fittings, valves, pumps, tanks. For more details write to National Carbon Company, Inc., Dept. PR.

The term "Karbate" is a registered trade-mark of

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation

30 East 42nd Street, New York 17, N.Y.

Division Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

Foreign Department: New York, U.S.A.

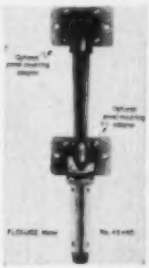
These products sold in Canada by Canadian National Carbon Co. Ltd., Toronto 4.

NEW EQUIPMENT and Manufacturers' Literature

For copies of manufacturers' literature or more information about products described on these pages write to the address shown, using the number shown for each item desired.

Flowmeter (Item 52)

A new variable-area gas flowmeter, "Flowguide," developed by Fischer & Porter Company has a wide-angle scale which can be read from within a 180° arc and is also rotatable for flexibility of installation. Extension below the metering tube carries a metering scale, and an indicator below the float permits direct reading of flow rate. The flowmeter is available in capacities ranging from 45 to 16,000 standard cubic feet of carbon dioxide per hour, 200 to 76,000 scfh. hydrogen, and comparable capacities for other gases. Although primarily designed for low pressure service, "flowguide" meters can be furnished to withstand 600 psig. working pressure in all sizes.



For further information write Fischer & Porter Company, Hatboro, Pa., referring by number to this PETROLEUM REFINER item.

Swivel Joints (Item 53)

Chiksan Company Catalog No. 50 describes over 500 different types and sizes of ball-bearing swivel joints. Also described are all-steel rotary hose, all-metal marine and barge hose, all-steel cementing and circulating hose, circulating heads and mud guns. Unions, blocks and thread compounds manufactured by Well Equipment Manufacturing Corporation and low pressure gas burners and warehouse and derrick stoves manufactured by Anchor Burner Company also are included.

For further information write Chiksan Company, 330 N. Pomona Avenue, Brea, Calif., referring by number to this PETROLEUM REFINER item.

Controls (Item 54)

A "completely redesigned" millivoltmeter-indicating controller, the Pyr-o-Vane controller, and a Protect-o-Vane controller designed to protect a furnace, oven or a process from excess temperatures have been introduced by Brown Instruments division of Minneapolis-Honeywell Regulator Company. Automatic control by the Pyr-o-Vane controller is provided by a light metal vane which moves in and out of an electrical field. The Protect-o-Vane is a companion piece for the Pyr-o-Vane controller and many of the components are interchangeable. It shuts off heating sources when temperatures go beyond a set limit and can also be used in conjunction with the company's ElectroniK line.

For further information write Minneapolis-Honeywell Regulator Company, 2753 Fourth Avenue South, Minneapolis, Minn., referring by number to this PETROLEUM REFINER item.

Drum Liner (Item 55)

"Visqueen" film a revolutionary bulk packaging development of the Visking Corporation, is said to eliminate or simplify problems in the handling and cleaning of petroleum product containers. Rectangular cartons, fiber drums, steel drums and other containers lined with "Visqueen" film tubing can be completely emptied without scraping, according to the manufacturer. Any remaining residue is squeezed from the lining which is pulled out of the container. The container itself can be discarded or returned for refilling, without the need of further cleaning, as the lining, which is said to be stick-proof, will not adhere to the containers or to the packaged products.

A clear, odorless, tasteless polyethylene film, "Visqueen" lining is said to be chemically inert and unaffected by most acids and alkalies. Other features claimed are low temperature flexibility, a nontoxic quality, and low-moisture vapor transmission.

A manual of technical information regarding "Visqueen" film drum liners, prepared by the company's research department and available upon request, includes a sample "Visqueen" film bag. Pointed out in the manual are the economics of using "Visqueen"; properties and characteristics of the film; and technique in applications for both steel drums and rectangular cartons. Thirty-two products are listed with which the lining is suggested for use.

For a copy write the Visking Corporation, Preston Division, Box GI410, Terre Haute, Ind., referring by number to this PETROLEUM REFINER item.

"Rustfree Steels" (Item 56)

Uniworld Research Corporation of America's group of electro-steel alloys called "super rustfree steels," SRSteels, are described in a pamphlet. Shown are SRSteel's high resistance against aqua regia, advantages of the steels, tensile strength, weldability, structure and electrical conductivity.

For a copy write Uniworld Research Corporation of America, 1302 Ontario Street, Cleveland 13, Ohio, referring by number to this PETROLEUM REFINER item.

Ion-Exchange Process (Item 57)

Water containing less than one part of ionic solids per 100 million parts of water can be produced by passage through a mixed bed of Amberlite ion exchange resins, according to the Resinous Products Division of Rohm & Haas Company which says the new ion-exchange process technique permits complete removal of inorganic salts without deviation from chemical neutrality, pH 7.0. Further uses for the process are being investigated in petroleum refining and other fields.

For further information write the Resinous Products Division of Rohm & Haas Company, 22 West Washington Square, Philadelphia, referring by number to this PETROLEUM REFINER item.

Stop Valves (Item 58)

A new line of forged steel stop valves, designed to fill the need for stop valves,

"Beats OLD-FASHIONED tube rolling half a dozen ways"

"Rolling condenser and heat exchanger tubes is a 'snap' since we got our AIRETOOL Tube Rolling Control. The work is faster and far more accurate and we've noticed other benefits too. There's less tube end corrosion . . . fewer tube failures . . . longer life from expanders . . . more protection to the tube sheet . . . uniformly tight tube joints. I wouldn't be without it now."

here's the BIG difference

This control box takes all the guesswork out of tube expanding. All you do is set the pre-calibrated dial for the tube size and metal type . . . insert an AIRETOOL G-800 or G-1200 ball bearing type expander and when the tubes are perfectly expanded the motor automatically shuts off. Thus unfailing mechanical means assure you positive results. For full details about this outstanding precision device or information on tube cleaners, expanders and their accessory tools, write The AIRETOOL Mfg. Co., 316 S. Center St., Springfield, Ohio.

AIRETOOL Outside Mounted Condenser Cleaners are safe, powerful and easy to use. A wide variety of brush and drill heads are available for removing any scale condition encountered. Illustrated is the AIRETOOL No. CC-450 for tubes ⅜" to 1½" I. D.

There's an AIRETOOL Tube Cleaner and Tube Expander for every type of Tubular Construction.

AIRETOOL MANUFACTURING COMPANY

SPRINGFIELD, OHIO

BRANCH OFFICES

New York, Philadelphia, Chicago, Tulsa, Houston, Baton Rouge

Representatives in Principal Cities

New Equipment

has been built by Edward Valves, Inc., East Chicago, Ind., and can be installed in almost any service where small OS&Y steel globe or angle valves are used. These valves, identified as the Fig. 444 series, have swing bolted packing glands and large packing chambers; interchangeability of parts; and bronze yoke bushings. Constructed of drop forged steel for greater strength, they are available with bolted or union bonnets in sizes ¼ thru 2 inches and with screwed or socket welding ends. Built of carbon or chromium molybdenum steel for two ranges of service conditions, they are rated for 600 pounds at 900° F. and 1500 pounds at 850° F. for steam, oil, and gas service. Bulletin 501 gives more details.

For a copy write Edward Valves, Inc., East Chicago, Ind., referring by number to this PETROLEUM REFINER item.

Gas Mask (Item 59)

A new high-efficiency gas mask, effective against hydrogen sulfide and petroleum vapors, announced by Willson Products, Inc., features an oversize canister filled with premium absorbent chemicals. This improved canister furnishes protection for a period twice as long as that required for U. S. Bureau of Mines approval. The mask is not air-supplied and should not be used inside storage tanks, tank cars, or any confined space where the oxygen content may fall below 16 percent. The mask is useful to tank gaugers, pumphouse men, pipeline inspectors, repairmen and others subject to hydrogen sulfide gas emanating from sour crude oils and raw distillates.

For further information write Willson Products, Inc., Reading, Pa., referring by number to this PETROLEUM REFINER item.

Safety Voice (Item 60)

Saf-T-Vox, a small and compact unit for the recording and reproducing of safety messages has been developed at General Electric Company's Electronic Park and adapted to the field of industrial safety by the American Allsafe Company of America. The unit enables the safety man to deliver a verbal warning at the danger point before the danger moment. As the individual approaches, an electric eye trips the starter,

Provides THAT "SWITCH IN TIME"

S&J

This S.&J. Level Alarm, Figure ST-4440, will automatically signal the rise or fall of fluid level past a predetermined point in a high pressure tank, tower or other vessel. It can be used to ring a bell, sound a horn or howler or flash a light that will warn operating personnel to correct unsafe or undesired conditions BEFORE they become critical. It can also be used to close or open electrical circuits, ground magnetos or close relays. There is an almost unlimited potential for the use of the S.&J. Level Alarm to actuate electrical instruments or controlling devices connected with high pressure processing, transfer and storage of petroleum products.

The body of this Level Alarm is of cast steel and is designed for working pressures up to 500 pounds. The vapor-proof switch box is equipped with a gasketed glass window for visual inspection of the interior mechanism. It employs no stuffing box whatsoever, but utilizes six pole magnets to actuate the mercury switch. The alarm is regularly supplied with one mercury switch, but additional switches can be mounted on the mounting plate, or special switches can be supplied on order at an extra charge. It is available in the fully automatic type only, and can be supplied with Underwriters' Listed Explosion-proof Switch Box. It is then designated as Figure ST-4440 UL.

SHAND & JURS CO.
BERKELEY, CALIFORNIA

NEW YORK CHICAGO HOUSTON LOS ANGELES SEATTLE

SHAND & JURS

New Equipment

and Saf-T-Vox tells him about the danger. It stops when he has passed. The unit employs a mechanism for handling a magnetic tape on which messages are recorded, an amplifier, a loudspeaker, and a starting trigger. Ten messages of ten seconds duration each can be repeated one at a time as the device is started.

For further information write The American Allsafe Company, Inc., 1245 Niagara Street, Buffalo 13, N. Y., referring by number to this PETROLEUM REFINER item.

Capillary Bleeder (Item 61)

Clapp Instrument Company has developed an integral capillary bleeder for use with the Acragage. Designed for use in pressure gages to be operated on sealed hydraulic systems, or wherever the pressure line must be purged, the new integral capillary bleeder permits complete purging of the air from the bourdon tube at all times. The manufacturer points out that it is impossible to completely evacuate air from bourdon tube, and that the resulting air bubbles left by this method of filling result in gage inaccuracies of as high as 4 percent of the maximum scale graduation. It is claimed that the new bleeder will therefore be of great value on sealed system pressure gages such as the diaphragm protected gage illustrated.

For further information write Clapp Instrument Co., Tracy Court, Webster, Mass., referring by number to this PETROLEUM REFINER item.

Acid Gloves (Item 62)

Industrial and acid gloves are described in a catalog section issued by The B. F. Goodrich Company. Various types are listed, complete with specifications and uses.

For a copy write The B. F. Goodrich Company, Akron Ohio, referring by number to this PETROLEUM REFINER item.

Water Tube Boiler (Item 63)

The design of Henry Vogt Machine Company, Inc.'s Class VI, bent tube boiler permits its adaptation to limited space conditions in industrial plants having diverse steam requirements. A large proportion of the boiler surface is exposed to the furnace. Side water walls may be incorporated without the use of headers when limited water cooling is required. Full water cooling can also be added. It is claimed that drum internals, correct proportioning of steam and water circulating tubes, and ample steam space and steam liberating surface insure commercially dry steam at all ratings. Steam purifiers can be added for higher quality steam. The boiler is designed and built to comply with ASME Code requirements.

For a bulletin write Henry Vogt Machine Company, Inc., 10th and Ormsby Streets, Louisville 10, Ky., referring by number to this PETROLEUM REFINER item.

Bronze Valve (Item 64)

Hancock bronze valves with "500 Brinnell" stainless steel seats and discs and a diaphragm construction claimed to be 125 to 230 percent stronger than found in usual bronze valves of similar type has been announced by Manning Maxwell & Moore, Inc. The valves are manufactured in sizes of ¼-2 inches and are available in globe and angle types, screwed ends. The valves are also designed for all pressures up to 150 psi. saturated steam. Non-shock cold water, oil, or gas, 300 psi.

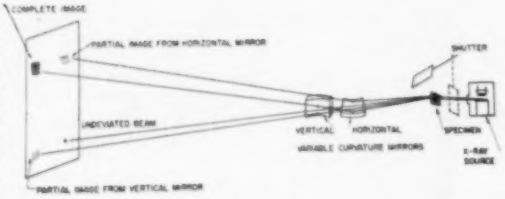
For further information write Manning, Maxwell & Moore, Inc., Watertown 72, Mass., referring by number to this PETROLEUM REFINER item.

Leak Detector (Item 65)

A Bulletin, "Veeco Mass Spectrometer Leak Detector," issued by Vacuum-Electronic Engineering Company, describes typical applications, wherever a vocuum, fixed pressure or special atmosphere must be maintained for extended periods of time; principle of operation, features, and data pertaining to vacuum testing and pressure testing with explanatory illustrations.

For Bulletin LD-81, write Vacuum-Electronic Engineering Company, 316 37th Street, Brooklyn 32, referring by number to this PETROLEUM REFINER item.

X-Ray Microscope (Item 66)



Internal details of materials through which light cannot pass are made visible by an X-ray microscope developed by General Electric Company. Lab researchers claim a 100-diameter magnification. The instrument operates on the principle that X-rays can be reflected from polished surfaces. The microscope consists of an X-ray tube and a pair of curved mirrors—made of platinum-coated slabs of fused quartz—which the X-rays strike at an angle of less than one-half degree, after having passed through the sample. The mirrors bend the rays to form a magnified X-ray image of the sample on a photographic film. The optical system, sample holder, and dials for making focusing adjustments are mounted in a compact metal unit, about half the size of a shoebox.

For further information write General Electric Company, Schenectady 5, N. Y., referring by number to this PETROLEUM REFINER item.

Flow Meter (Item 67)

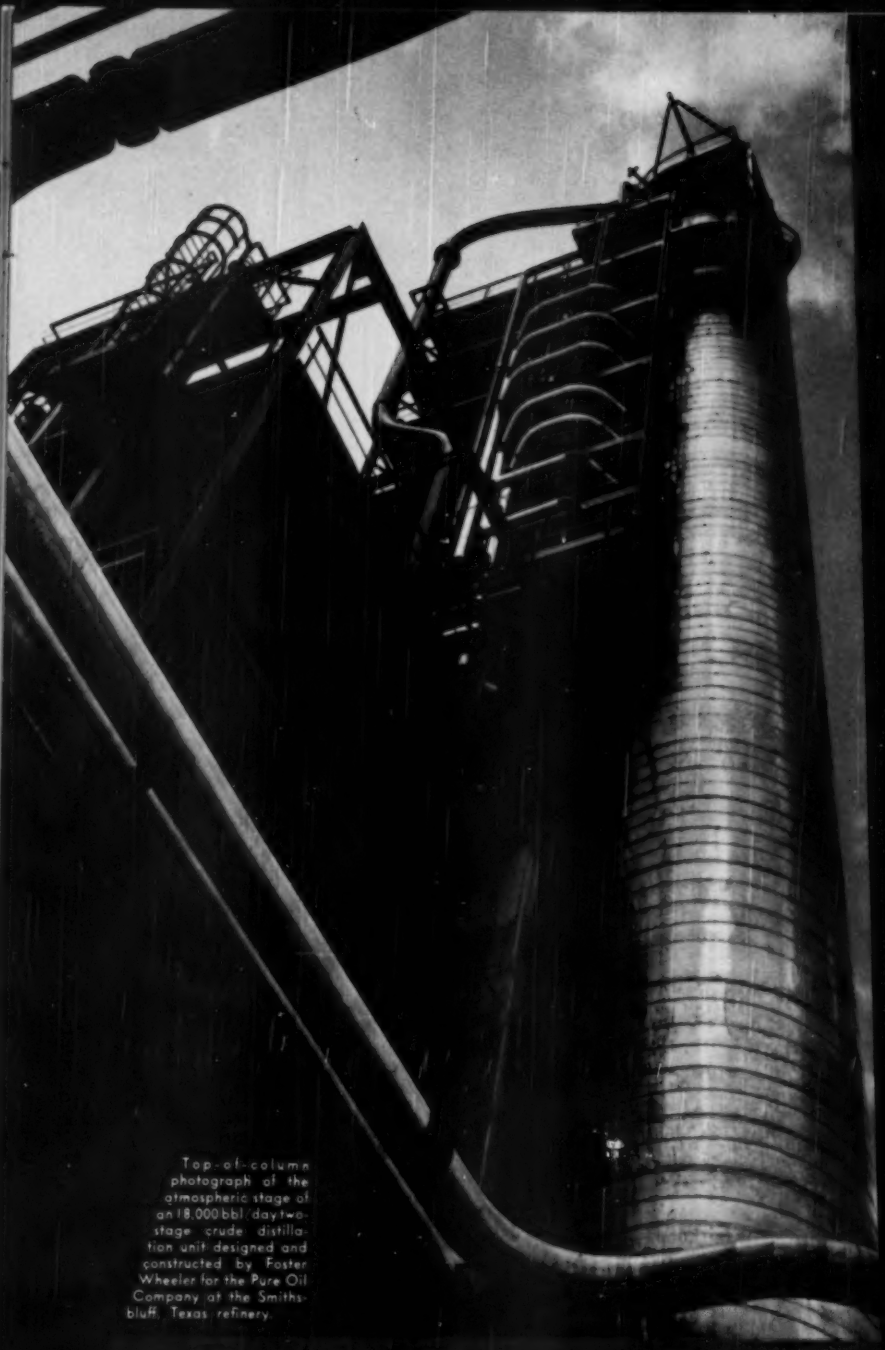
Equipped with an internal, adjustable pulsation dampener, Model 202 recorder, a bellows type flow meter, is said to be rupture-proof. According to the manufacturer, this means a differential pressure up to the pressure rating of the housings may be imposed across the bellows mechanism without any damage whatsoever. The dampener controls the rate of flow of the hydraulic fluid (within the bellows mechanism) from one bellows chamber to the other. The adjustment may be made while the meter is in service. Hydraulic fluid is permanently sealed within the bellows mechanism, protecting the pulsation dampener assembly from plugging or loss of effectiveness.

For further information write Barton Instrument Corporation, 1429 South Eastern Avenue, Los Angeles 22, referring by number to this PETROLEUM REFINER item.

Voltage Regulators (Item 68)

The new line of electronic voltage regulators is described in two new catalogs of Sorensen and Company, Inc. Catalog No. A-1049 gives specifications of the standard voltage regulators for the control of a.c. power, including sizes and types not previously listed. Catalog No. B-1049 describes the newly added power sources and supplies.

For copies write Sorensen and Company, Inc., 375 Fairfield Avenue, Stamford, Conn., referring by number to this PETROLEUM REFINER item.



five
products

3

gaps

one fraction
no gap — no overlap

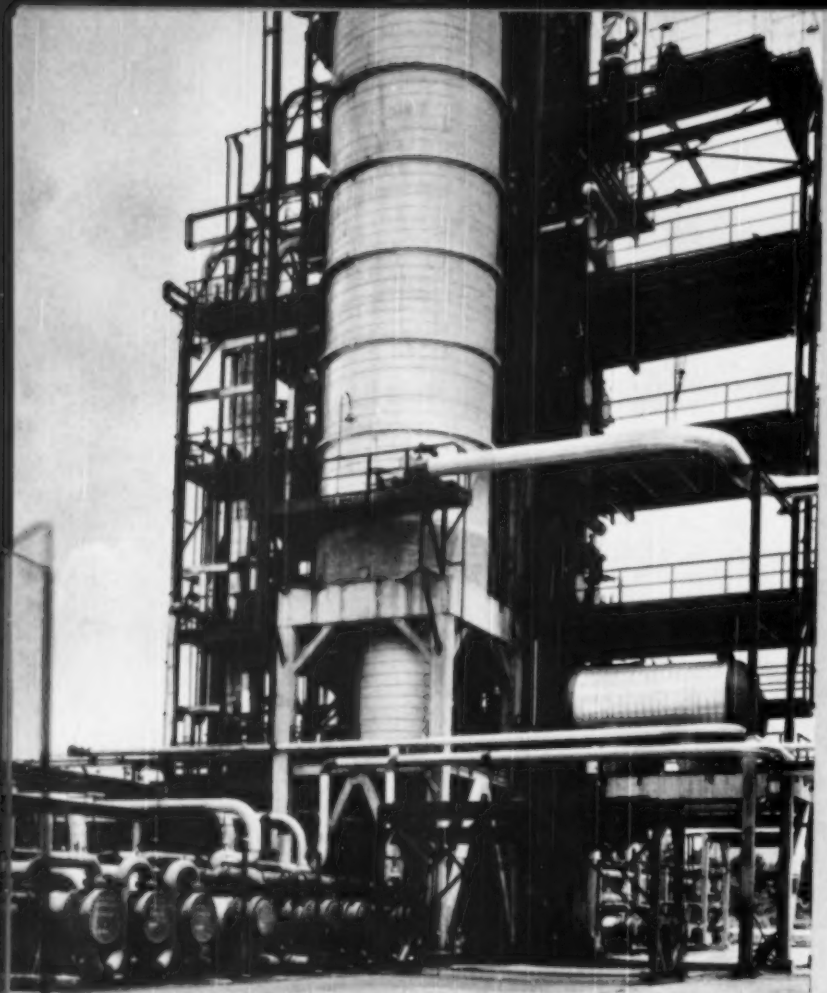
Cut	IBP	EBP	Gap
Top		248	
2	254	312	
3	312	362	
4	394	532	32
5	550	664	+18

Degrees F

Top-of-column photograph of the atmospheric stage of an 18,000 bbl. day two-stage crude distillation unit designed and constructed by Foster Wheeler for the Pure Oil Company at the Smithsbluff, Texas refinery.

FOSTER WHEELER CORPORATION

165 BROADWAY, NEW YORK 6, NEW YORK



designed for "fast turnaround"

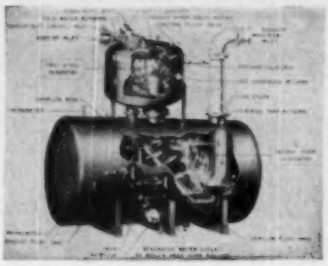
Traveling crane available for removal of any exchanger in the ground level exchanger bank . . . also . . . movable cranes on three roomy column platforms for servicing condensers.

These and other "shutdown features", designed into this crude unit, maintain process equipment at maximum efficiency and contribute effectively to a "fast turnaround" and a high overall operating economy.

FOSTER WHEELER CORPORATION

165 BROADWAY, NEW YORK 6, NEW YORK

Deaerating Heater (Item 69)



A new deaerating heater design of Graver Water Conditioning Company is available to reduce the oxygen content of boiler feedwater to less than 0.005 ml. per liter measured by the ASTM Referee method or modified Winkler test "regardless of rapid load variations or unusual operating conditions." Carbon dioxide is also removed. Bulletin W101 describes the heaters, available in sizes up to 2 million pounds per hour. The second stage of each heater is made for individual plant conditions and for the desired storage capacity.

For a copy of the bulletin write Graver Water Conditioning Company, 216 West 14 Street, New York 11, referring by number to this PETROLEUM REFINER item.

Bladeless Trash Pump (Item 70)

Fairbanks, Morse & Company's bladeless trash pump, mentioned in January PR, is described in more detail in a company bulletin. Included are vertical shaft pump descriptions; details of construction; and drive modifications such as universal flexible shaft drive, open and column enclosed shaft drive. Also explained are horizontal shaft pumps. Principal dimensions and selection tables are given for both verical and horizontal shaft. Eighteen other pump types are shown.

For a copy of Bulletin 5400K-1, write Fairbanks, Morse & Company, 600 South Michigan Avenue, Chicago 5, referring by number to this PETROLEUM REFINER item.

Plastic Coating (Item 71)

Vinyl-Cote, a new plastic coating for petroleum and chemical tanks, announced by Glidden Company, is said to be an impervious tank lining which does not blister and which eliminates the peeling common to old-style plastic coatings. Vinyl-cote is a five-coat system with each coat a different color. It is said to be almost totally unaffected by oils, greases and petroleum solvents and stands up against aromatic solvent. However, it is soluble in the ketone and ester group of solvents and its resin films will not withstand operating temperatures above 180° F.

For further information write Glidden Company, 11001 Madison Avenue, Cleveland 2, Ohio, referring by number to this PETROLEUM REFINER item.

Ammonia Application (Item 72)

Termed V/W compressors because of the arrangement of its cylinders, a new line of high speed refrigeration compressors for ammonia application has been developed by York Corporation to handle from 15 to 275 hp. equivalent of refrigeration. It is claimed that the new line results in a greater freedom from vibration similar to the finest of airplane engine designs. Upper floor mounting without special foundations "is made possible by complete static and dynamic balance of the compressors." Other features claimed are automatic unloading of cylinders, capacity reducers, precision-built ring plate type suction and discharge valves, etc.

For further information write York Corporation, York, Pa., referring by number to this PETROLEUM REFINER item.

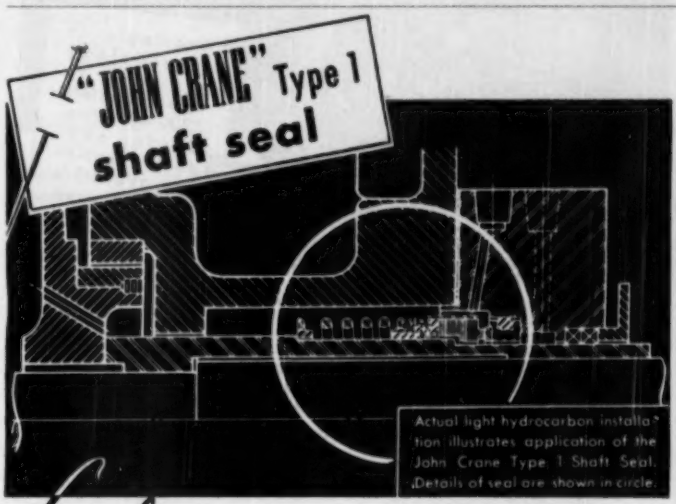
Steam Generators (Item 73)

Foster Wheeler Corporation's booklet on packaged steam generators gives dimensional drawings, heating surface in square feet, tube sizes, and capacities in pounds per hour. Also included are diagrams for firing arrangements for coal-oil-gas package steam generators. Components, design, superheat installation, accessories, firing, and efficiency and economy of the steam generators are also described. Design pressures are included for 150, 300, 500, and 900 pounds.

For a copy of Bulletin PG-49-13 write Foster Wheeler Corporation, 165 Broadway, New York 6, referring by number to this PETROLEUM REFINER item.

Speed Reducers (Item 74)

Parallel shaft sleeve bearing speed reducers of The Falk Corporation are described in Bulletin 1110. Included are


"JOHN CRANE" Type 1
shaft seal
Actual light hydrocarbon installation illustrates application of the John Crane Type 1 Shaft Seal. Details of seal are shown in circle.

Seals propane and other light hydrocarbons

"Service-Proven" on Refinery and Pipe Line Installations

The "John Crane" Type 1 Shaft Seal will mean outstanding sealing performance on practically all your petroleum services, *including the effective sealing of Butane, Propane and other light hydrocarbons.*

This seal is being widely used today for all general petroleum services—is suitable even for pressures to 500 psi.

Design features insure satisfaction: It is a single unit and requires no auxiliary lubricating system. Proper balancing of sealing faces, and the selection of proper face widths for each job insure leak-proof operation. A quench gland is added as an "extra" safety factor, to permit circulation of water or oil.

Proof of the unequaled service of this seal is found in its use by many major refineries. Practically all leading pump manufacturers, too, agree that this seal is the best means for sealing hydrocarbons. Most manufacturers furnish it as standard equipment.

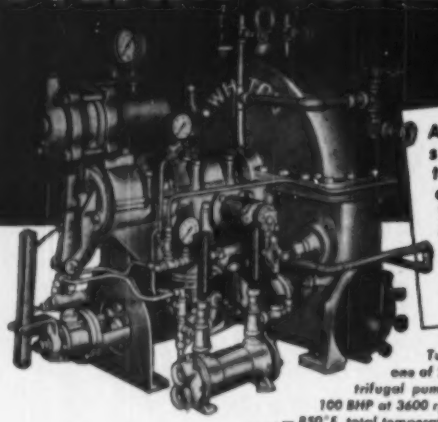
Write for further information. A special booklet describes the design features in detail. Or, if you wish, just send the serial number and name of your pump's manufacturer. Drawings can be prepared to show application of this seal to your service.

Crane Packing Company, 1820 Cuyler Avenue, Chicago 13, Illinois.

JOHN CRANE
PACKINGS AND MECHANICAL SEALS
CRANE PACKING COMPANY
CHICAGO
Offices in All Principal Cities in United States and Canada

Whiton SOLID STEEL ROTOR

STEAM TURBINES



Available in single stage types up to approximately 1200 HP rating. Center supported frames are available when required.

Turbine shown above is one of 24 ordered to drive centrifugal pumps designed to deliver 100 BHP at 3600 rpm with steam at 850# — 850° F. total temperature exhausting against 42# gauge back pressure.

• SIMPLE DESIGN FOR ACCESSIBILITY

Inlet and exhaust connections are located in lower half of casing which is horizontally split to allow easy access to all internal parts. Rotating unit including bearings and governor head may be removed without disturbing alignment of the unit.

• RUGGED CONSTRUCTION FOR RELIABILITY

Whiton rotors are made from a solid steel forging with semi-circular buckets milled in the rim to give strength where it is needed. End thrust is minimized because the path of the steam is always at right angles to the shaft.

• SAFETY DEVICES FOR TROUBLE-FREE OPERATION

Standard equipment includes Constant Speed Governor with V-Ported Governor Valve . . . Emergency Governor with Independent Valve . . . Steel Plate Steam Strainer . . . Two oil rings per bearing supplemented by water cooling . . . Sentinel Type Casing Relief Valve . . . Additional accessories available as required.

THOUSANDS OF SATISFACTORY INSTALLATIONS SINCE 1911

Write for complete information

WHITON MACHINE COMPANY
NEW LONDON CONN. U.S.A.
also makers of Fine Lathe Chucks • Gear Cutting Machines • High Production Milling Machines • Centering Machines

New Equipment

method of selection, horsepower rating tables, torque capacity tables, order guide dimensions, backstops, flexible couplings. Advantages claimed are symmetrically arranged herringbone gears, providing balanced loading; double ended shafts; sleeve bearings; freedom from oil leakage; and quiet operation.

For a copy of the bulletin write The Falk Corporation, Milwaukee, Wisc., referring by number to this PETROLEUM REFINER item.

Control Valves (Item 75)

Hammel-Dahl Company's new 2000 series Saunders patent diaphragm control valves are designed primarily to handle corrosive fluids or gases or any slurry or fluid carrying solids in suspension which would plug the bowl of a double seated control valve or lodge in the guide section of a Venturiflo (angle) valve. They are useful also on many vacuum applications. The oversize structure will permit 50 psi. air loading on the largest size, up to 250 psi. on the smaller sizes. The valves can be supplied with cast iron bodies, with or without rubber, glass or lead lined, as well as type 316 stainless, monel, everdur, nickel, duriron and aluminum, while the standard body diaphragm is either rubber or neoprene. Hycar, butyl and tygon can also be supplied.

For further information write Hammel-Dahl Company, 243 Richmond Street, Providence 3, R. I., referring by number to this PETROLEUM REFINER item.

(Note—This illustration erroneously appeared with another item on page 211 of the December Refiner.)

Diesel Engines (Item 76)

Diesel engines for stationary installations are described in The National Supply Company's Bulletin 4812 which features "60 years of engine research and production development," and installations. Included are more than 100 engine specifications showing a range in power from the 6-cylinder, 175-hp. engine with 8½ by 10½-inch bore and stroke, to a 8-cylinder, 1500-hp. engine with 14½ by 20-inch bore and stroke.

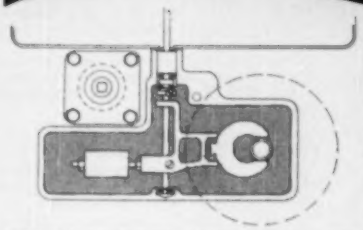
For a copy write The National Supply Company, Superior Engine Division, Springfield, Ohio, referring by number to this PETROLEUM REFINER item.

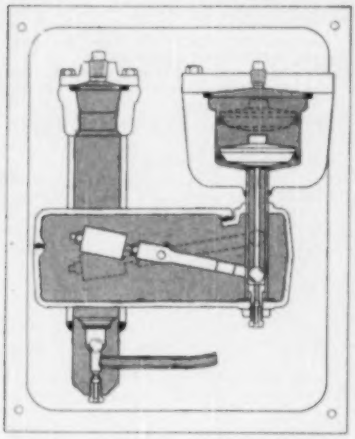
Ammonia Application (Item 72)

Type B, a corrosion resisting resin coating, has been developed by Brooklyn Polytech Institute in conjunction with Carboline Company's research program. The coating is made for application at room temperature, requires no mixing and is flexible when dry. "Bending the finished coating over a ⅛-inch radius bar at —20° F. does not harm it." Chief advantages claimed for this coating over the polyvinyl chloride and chlorinated rubber coatings are 90 percent resistance to acids of higher concentration

MORE ACCURATE . . . *because it has* MORE POWER *and Less Friction*

The HAYS-PENN MAGNA-CLUTCH MECHANICAL FLOW METER





For HIGHEST ACCURACY

Maximum Power, greatest mercury displacement because of largest float (3.75 in. diam.) and longest float travel (1.5 inches).

Minimum Friction, independent of working pressure because of elimination of pressure-tight bearing, internal knee bearing and shaft end-thrust bearing.

Highest ratio of power to friction.

Precise calibration check at 50 percent of differential available at extra cost.

For LOWEST MAINTENANCE

Manometer accessible without disconnecting piping.

Only one internal moving part (the float).

No bearings to service.

Mercury volume not critical.

Manometer level not critical.

Mercury easily drained.

Positive mercury check valves.

For COMPLETE SAFETY

No leakage possible of inflammable, explosive, or toxic fluids because of no pressure-tight bearings.

For UTMOST FLEXIBILITY

Field adjustable for any differential range:

35" tube from 17" to 35" water
100" tube from 50" to 100" water
200" tube from 100" to 200" water
400" tube from 200" to 400" water
750" tube from 400" to 750" water
1500 or 2500 PSI working pressure

For SPECIAL FEATURES

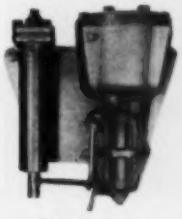
Any meter may be furnished with any or all of the following features:
Dual (wide range) recording pen.
Simple, accurate integrator.
Temperature and/or pressure pens.

The Hays Corporation, Michigan City 10, Indiana

The HAYS CORPORATION
COMBUSTION & INDUSTRIAL INSTRUMENTS & CONTROLS
MICHIGAN CITY, INDIANA, U.S.A.

HAYS-PENN *Electric* **FLOW METERS**

1000 P.S.I.



2500 P.S.I.

AREA METER 2" and 4"

LOW PRESSURE

SEND FOR BULLETIN 49-915

up to 125° F.; resistance to higher liquid temperatures (180-200° F.); and resistance to such solvents as the alcohols and straight chain chlorinated and aromatic hydrocarbons.

For further information write Carboline Company, 7603 Forsyth Boulevard, St. Louis 5, referring by number to this PETROLEUM REFINER item.

Solvents (Item 78)

A technical description of solvents and solvent oils produced by Pennsylvania Industrial Chemical Corporation, is contained in a new brochure describing the characteristics and typical analyses of Picco aromatic petroleum naphthas, coal tar naphthas, heavy naphthas, coal tar heavy naphthas, solvent oils and heavy solvent oils. Common applications are cited for each. Evaporation rates and their meanings, solvent power analysis such as the Kauri-Butanol and analine point methods, solvent handling, explosive mixtures of solvents and physiological actions of solvents are also given.

For a copy write Pennsylvania Industrial Chemical Corporation, Clairton, Pa., referring by number to this PETROLEUM REFINER item.

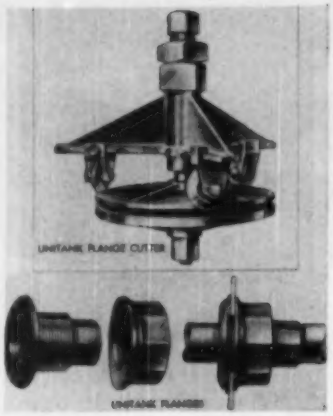
Tube Heat Exchanger (Item 79)

Dimension tables for single and two-pass models are given in Young Radiator Company's catalog on its new type "R" removable tube bundle shell and tube heat exchangers.

For a copy of Catalog No. 1149 write Young Radiator Company, Racine, Wisc., referring by number to this PETROLEUM REFINER item.

Flange Cutter (Item 80)

The Unitank flange, used in conjunction with the Unitank flange cutter, is a simplified method of connecting pipes to the outside or inside of a tank in only a few minutes, according to the manufacturer, American Pipe & Steel Corporation. Made up of a flange body and a tightening nut, the flange is a machined,



malleable casting with a tensile strength of 50,000 pounds. It is available in pipe sizes ½, 1, 2, 3, 4, and 6 inches. The cutter which operates on a combination punching and shearing can-opener principle, is said to be capable of cutting through a 3/16 inch or 7-gauge thickness.

For further information write American Pipe & Steel Corporation, Alhambra, Calif., referring by number to this PETROLEUM REFINER item.

Back Pressure Relief Valve (Item 82)

Type 135VW back pressure and relief valve of Klipfel Valves, Inc., a division of Hamilton-Thomas Corporation, is said to maintain steam pressure at points between 0 and 20 psi. Type 136VW is an atmospheric relief valve for vacuum service. Both valves are suitable for heating systems, power plants and process applications where close regulation of large quantities of steam is required.

For further information write Klipfel Valves, Inc., Division of Hamilton-Thomas Corporation, Hamilton, Ohio, referring by number to this PETROLEUM REFINER item.

Centrifugal Pump (Item 81)

For installations with flooded suctions, the new line of straight centrifugal pumps announced by Marlow Pumps, are offered in close or long-coupled construction, 1 to 4-inch sizes with capacities from 10 to 1000 gallons per minute. The unit consists of casing, impeller with shaft sleeve and the driving motor which is available from ½ to 30 hp. Pump operates in vertical or horizontal position and embodies advanced hydraulic principles. Features include a sealing ring at the suction inlet and deep-groove oversize ball bearings sealed against dirt and moisture; and an enclosed-type impeller.

For further information write Marlow Pumps, Ridgewood, N. J., referring by number to this PETROLEUM REFINER item.

Cylindrical Valve (Item 83)

A non-lubricated cylindrical plug industrial control valve, providing leak-proof shut-off while eliminating contamination, developed by Minneapolis-Honeywell Regulator Company, provides "leak-proof service without the use of a lubricant." The new design includes a permanent seal at the plug stem, sealing packing at the base of the plug, and a fixed-load spring, combined with a closer dimensional tolerance and micro-finish on the plug and body bore. Torque tests show that the cylindrical valve's greatest torque requirement, about 250 inch-pounds at a line pressure of 250 psi., was equivalent to a force of only 12½ pounds acting on a lever arm 20 inches long.

For further information write Minneapolis-Honeywell Regulator Company referring by number to this PETROLEUM REFINER item.

Pressure Vessels (Item 84)

A. O. Smith Corporation's Bulletin No. V-52 on multi-layer manufacture and assembly of pressure vessels is the third in a series of five on its line of pressure vessels. Bulletins to be available shortly are on multi-layer design and engineering; multi-layer penstocks; and multi-layer specifications.

For a copy of Bulletin No. V-52 write A. O. Smith Corporation, 3533 N. 27th Street, Milwaukee, Wisc., referring by number to this PETROLEUM REFINER item.

Distillation (Item 85)

The principles of compression distillation, which has been used extensively on ships for distilling salt water, and its present industrial applications are described in a folder of Arthur D. Little, Inc. Distinctive features claimed for compression distillation are 1) low cost of operation, 2) production of sterile water obtained, 3) elimination of cooling water, 4) simplicity of operation, and 5) flexibility of compressor drive by either electric motor, diesel, gasoline, steam, or gas turbine. Uses include making fresh water and the concentrating of industrial solutions by operating at lower temperatures, higher economy, with longer runs between cleaning shutdowns, and with easier cleaning than steam-fired stills.

For further information write Arthur D. Little, Inc., 30 Memorial Drive, Cambridge 42, Mass., referring by number to this PETROLEUM REFINER item.

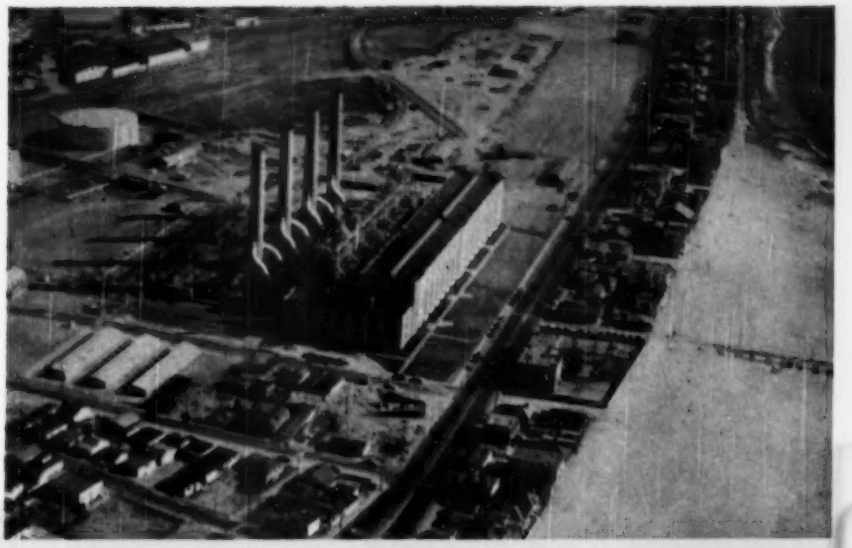
Formaldehyde (Item 86)

Celanese Corporation of America is offering a formaldehyde technical data brochure on specifications, physical properties, uses, methods of analysis, toxicology, first aid, and general precautions. Also included are data on storage and handling, shipping and unloading for tank cars, tank trucks, drums, cleaning procedure, and heat losses. A temperature-density table claiming 0.3 percent accuracy is also given.

For a copy write Celanese Corporation of America, 180 Madison Avenue, New York 16, referring by number to this PETROLEUM REFINER item.

Gas Generators (Item 87)

Two inert gas generators, models 1 MIHE and 2 MIHE, have been developed by C. M. Kemp Manufacturing Company and are rated at 1000 and 2000 cfh., respectively. Ratio control ad-



HELPING TO MAKE THE WONDERS *of* SO. CALIFORNIA *more wonderful*

The 280,000 kw Redondo Steam Station was constructed to keep pace with the rapidly growing power demands of this region. Semi-outdoor design combines economy of construction with operating comfort and convenience and the entire structure has been built to resist the stress of possible earthquake shock. Unique is the provision for control of marine growth through thermal shock during periodic reversal of salt water flow in the two 2,000 foot intake and discharge tunnels which obtain condenser circulating water from the Pacific Ocean.

Stone & Webster Engineering Corporation designed and constructed the Redondo Steam Station for Southern California Edison Company.

STONE & WEBSTER ENGINEERING CORPORATION

A SUBSIDIARY OF STONE & WEBSTER, INC.

Presenting

a pictorial record of standard and special built HEAT TRANSFER EQUIPMENT

by Vogt

Write for a copy of Bulletin HE-5, on your letterhead.

You are invited to send for this record of ingenuity in heat exchanger design and construction.

Shown, among examples of the many types we build, are units for diversified applications, high pressures, and special operating conditions as well as conventional types for ordinary exchanger services in petroleum refineries, chemical plants, process industries, power plants, etc.

Thousands of installations in successful operation attest to Vogt's ability to give effective help in the solution of heat transfer problems peculiar to a wide variety of operating conditions.

Vogt FOR BETTER HEAT EXCHANGERS

HENRY VOGT MACHINE CO.
INCORPORATED
LOUISVILLE 10, KENTUCKY
BRANCH OFFICES: NEW YORK, PHILADELPHIA, CLEVELAND, CHICAGO, ST. LOUIS, DALLAS

justs for manufactured, natural, propane, butane or refinery gases. The inert gas analysis of 87-88 percent nitrogen and 13-12 percent carbon dioxide is absolutely maintained at any point from 20 to 100 percent of rated capacity. Adjustment can be set to be free of oxygen in the presence of a small amount of combustibles, or completely free of combustibles in the presence of a small amount of oxygen.

For a descriptive booklet write C. M. Kemp Manufacturing Company, 405 E. Oliver Street, Baltimore 2, Md., referring by number to this PETROLEUM REFINER item.

Floor Gratings (Item 88)

Custom made floor gratings for walkways, platforms and stairs in refineries, industrial plants, factories, power houses, boiler rooms, water works, and sewage plants are offered by Borden Metal Products Company. The gratings are mechanically locked under hydraulic pressure, all slots are above neutral axis of bearing bars, thus maintaining strength. Cross bars are designed to permit lateral bracing. No heat is applied.

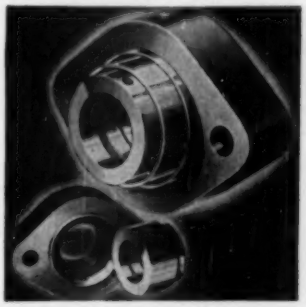
For bulletin write Borden Metal Products Company, 884 Green Lane, Elizabeth, N. J., referring by number to this PETROLEUM REFINER item.

Motor Drive (Item 89)

To satisfy new applications for a smaller, less expensive, all-electric variable-voltage type of adjustable-speed motor drive to operate on alternating current, Reliance Electric & Engineering Company has designed a new V-S unit, available at the outset in ¾, 1, 1¼ and 2-hp. sizes. Designed and built to operate on single-phase a.c. power with "round-the-clock" speeds ranging from 290 to 2300 rpm. at rated output and at 80 rpm. for short periods or at light load, the drive provides stepless speed selection and adjustment through this operating range.

For a copy of Bulletin D-2101 write Reliance Electric & Engineering Company, 1111 Ivanhoe Road, Cleveland 10, Ohio, referring by number to this PETROLEUM REFINER item.

Pressure Seal (Item 90)



An improved high pressure seal, designed to meet the extraordinary sealing requirements of equipment handling hydrocarbons under high pressures and temperatures, and developed by Felt Products Manufacturing Company, incorporates improved control and balance of hydraulic pressures; a reduction in the number of parts; and a simplified cooling method. Seals are designed to handle a variety of liquids at pressures up to 600 psi. and temperatures up to 250° F. in centrifugal pumps and other equipment handling crude oils, gasoline, propanes, etc.

For a copy of the data sheet write Felt Products Manufacturing Company, Packing Division, 1508 Carroll Ave., Chicago 7, referring by number to this PETROLEUM REFINER item.

Meters (Item 91)

How automatic compensation for pressure or temperature variations, or for both, are achieved in flow measurement of gases, liquids or other fluids with Hagan Corporation's compensated ring-balance meters is explained in company Bulletin M-51. A schematic diagram shows how a corrected record is automatically and continuously produced—with the chart also showing uncorrected flow. A built-in integrator automatically totalizes the corrected flow. Another diagram illustrates installation of a pressure and temperature compensated hagan ring-balance flow meter.

For a copy write Hagan Corporation, Hagan Building, Pittsburgh 30, referring by number to this PETROLEUM REFINER item.

Chromium Chemicals (Item 92)

Concise data on bichromate of soda, its manufacture, and its principal uses

Pump Packing Troubles

may mean costly shutdowns. Packing troubles ALWAYS mean higher operating costs. Have you tried Centrifugal Pumps which require NO packing? Most satisfactory for pumping acid and other corrosive liquids.

Descriptive Bulletin on Request

THE EDWARD SOPH CO.

Houston 2, Texas
726A M&M Bldg.
Phone Charter 4-8189

Tulsa 5, Okla.
202 E. 18th St.
Phone 3-6659

SIMPLIFIED
Stainless
FABRICATION
with FLOWLINE
STAINLESS WELDING FITTINGS
Any stainless steel piping system can be constructed with a minimum of equipment, using FLOWLINE stainless steel welding fittings, simply by straight cutting of tubes to desired lengths and plain butt welding. Fitting and welding time is thereby reduced, and a cleaner, lastingly efficient system is assured, since pockets and sharp corners that cause pressure drop are eliminated. FLOWLINE fittings can be cut out of the line and used again.
FLOWLINE stainless welding fittings are made in Stainless Types 304, 316, and 347; to match pipe and tubing of various wall thicknesses in sizes from ⅛" through 12". Send for Bulletin S-310 which gives complete specifications and list prices of the world's most complete line of stainless steel welding fittings.
WELDING FITTINGS CORP.
NEW CASTLE, PENNSYLVANIA

and six methods of analyzing sodium bichromate are discussed in Diamond Alkali Company's chromium chemicals handbook. Similar information is also given for sodium chromate and bichromate.

For a copy write Diamond Alkali Company at nearest sales offices or 300 Union Commerce Building, Cleveland 14, Ohio, referring by number to this PETROLEUM REFINER item.

Jet Ejectors (Item 93)

Evactors, steam jet ejectors for high vacuum, developed by Croll-Reynolds Company, Inc., are available in single-stage sizes, designed to handle loads at a pressure of three inches mercury absolute, or higher, to five-stage units. Also covered are priming evactors, thermo-compressors, regenerative evaporators and aqua-vactors, which use water instead of steam as the motivating power.

For a catalogue write Croll-Reynolds Company, Inc., 17 John Street, New York, referring by number to this PETROLEUM REFINER item.

Tool Steel (Item 94)

Marketed under the name B-47 hot work steel, the new alloy of Allegheny Ludlum Steel Corporation is a combination of chromium, tungsten, cobalt, vanadium and iron said to be resistant to shock and abrasion at elevated temperatures. Suggested applications include brass extrusion dummy blocks and dies, valve extrusion die inserts, forging die inserts, forging press dies and hot punch tools.

For a copy of B-47 blue sheet write Allegheny Ludlum Steel Corporation, Room 2036, Henry W. Oliver Building, Pittsburgh 22, referring by number to this PETROLEUM REFINER item.

Center Finder (Item 95)

Model PF "pipe fitters special" (Interstate Sales Company) is a compact

tool with the main features of the larger tool, Model C-1, but "is handier." The revolving dial with the 4 levels is marked in both degrees and inches per foot. The tool weighs 6 ounces and measures 6 by 4 by 1¼ inches over-all. Other features are a center-punch made of No. 416 stainless steel. The point is hardened and will punch milled steel. The frame is a magnesium casting, and all other parts are brass or stainless steel.

For further information write Interstate Sales Company, 123 E. 18th Street, New York 3, referring by number to this PETROLEUM REFINER item.

Piping Systems (Item 96)

Charts, tables, graphs, condensations and discussion of pipe specifications, welding data, design formulas, metallurgical information and other engineering data are contained in Midwest Piping & Supply Company, Inc.'s catalog on welding fittings. There are digests of about 20 ASA and ASTM specifications, covering pipe, fittings and flanges, with a discussion of code requirements for pressure piping.

For a copy of the catalog write Midwest Piping & Supply Company, Inc., St. Louis, referring by number to this PETROLEUM REFINER item.

Metallic Soaps (Item 97)

Mallinckrodt Chemical Works has announced addition of aluminum stearate technical D-50 to its line of metallic soaps for use in the lubricating grease industry. "Tests have shown D-50 greases, at low soap concentrations, to possess good resistance to mechanical breakdown upon working and to have high dropping points, even texture, and superior resistance to bleed." "Aluminum soaps for Lubricating Grease Manufacture" contains descriptions of the company's major gel-forming aluminum stearates plus comprehensive discussions of good manufacturing techniques, the advantages of using combinations of aluminum soaps, etc.

For a copy and soap samples write Mallinckrodt Chemical Works, Second

Superior-built Absorber 80 ft. long and 102 inches in diameter.

Topnotch teamwork gives you a *SUPERIOR* job!

The above absorber, built for a West Texas gasoline installation, is proof of how all Superior departments work as a team to produce plant equipment of Superior quality.

Because of the close cooperation between our engineering, drafting and production departments, you get your finished job AS PLANNED AND AS SPECIFIED. Try us! WE CAN DO THE JOB!

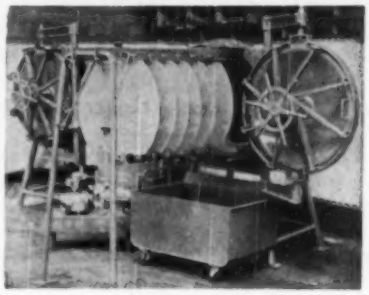
Also
FRACTIONATING TOWERS - HEAT EXCHANGERS - SCRUBBERS AND RETUBING OF HEAT EXCHANGERS

API-ASME AND ASME CODE CERTIFIED BY NATIONAL BOARD

For Information or Estimates Call Amarillo 4395

SUPERIOR MANUFACTURING COMPANY
AMARILLO, TEXAS

Emulsified or Free Oils Effectively Removed from Condensate with the BLACKBURN-SMITH REFINER



Outstanding Advantages

1. Breaks the tightest emulsion of oil in water
2. Reduces contamination to less than .1ppm.
3. Produces pure, clean condensate
4. Saves boiler tubes

Contaminated Condensate Formerly Wasted Can Now Be Re-Used After Filtration Through the Refiner

Proved in service . . . saves heat units and fresh water . . . no back-washing . . . reduces boiler maintenance costs . . . improves boiler efficiency . . . simple and inexpensive to operate . . . requires little space.

Write for catalog. Engineering assistance gladly furnished.

Phone: Hoboken 3-4425 — **The Blackburn-Smith Mfg. Co., Inc.** — 96 River Street, Hoboken, New Jersey — *Subsidiary of Condenser Service & Engr. Co., Inc.* — Phone: Rector 2-9360

DON'T BE A LATE STARTER

1950 promises to be a tough, competitive year. One way you can get a fast start on profitable operation is to use standard Wilson-Dudgeon Tube Expanders to help solve your production or maintenance problems on tubular apparatus. Backed by 97 years of solid experience, Wilson-Dudgeon Tube Expanders will assure you of fast, easy, reliable tube rolling to cut down-time and increase production-time. Here are two of the profit-making Wilson-Dudgeon Tube Expanders:

Wilson-Dudgeon Model 38 Tube Expander for tubes 1" O.D., up. Self-feeding, parallel rolling and flaring action seats tubes quickly and solidly.

Wilson-Dudgeon Model 41 Tube Expander, parallel rolling, self-feeding with ball bearing thrust collar for rolling heat exchanger tubes ½" O.D. to 2½" O.D., into tube sheets to 6".

No matter what your tube expander problem, you can be sure of getting a Wilson-Dudgeon Tube Expander that will fit your specific application. Write us, giving full details or send for Bulletin 380.

CUT FUEL COSTS *with* WILSON TUBE CLEANERS

Remember—1/16" of scale often wastes 10%, or more, in fuel. A Wilson Tube Cleaner makes short work of the toughest deposits . . . cleans both ferrous and non-ferrous straight or curved tubes. Air, steam, water or electrically driven cleaners available for tubes 3/8" I.D., to the largest ever cleaned. Write for Bulletin 47-A.

THOMAS C. WILSON, INC., 21-11 44th AVENUE, LONG ISLAND CITY 1, N. Y.

TW-77a

WILSON TUBE CLEANERS

HOW AQUA-VACTORS PRODUCE VACUUM WITH WATER

CR Aqua-Vactor Uses Water as Motivating Fluid

Combining the advantages of the steam jet ejector and the low cost of water, the Croll-Reynolds AQUA-VACTOR is employed economically in many instances. Low in first cost and with no moving parts, the water jet may be used to mix liquids, serve both as an ejector and condenser, and in isolated cases, handle air and gases.

While not as efficient as a steam jet ejector, the AQUA-VACTOR becomes economical when the pressure of water is being dissipated for other process work. In such cases it may be possible to use the AQUA-VACTOR either as an ejector alone or as both an ejector and a condenser using water under pressure to operate the AQUA-VACTOR and using the exhaust from the AQUA-VACTOR for other processes.

The illustration shows a type SW EVACTOR using steam in the first stage and water in the second stage. Here the AQUA-VACTOR is used both as an ejector and as a condenser, handling air and, at the same time, condensing steam from the first stage. Of interest to engineers with corrosion problems, the steam stage in the illustration is constructed of carbon including the steam nozzle. The carbon is incased in cast iron giving the equipment the strength of iron and the corrosion resistance of carbon.

For more complete information concerning the application of the AQUA-VACTOR, or any type of steam jet EVACTOR, write today to:

CROLL C R REYNOLDS

CROLL-REYNOLDS CO., INC.

17 John Street

NEW YORK 7, N. Y.

in Mechanical Drive Turbines

TYPE DP

For flexible speed control, performance accuracy, and on-the-job reliability, you can't beat a General Electric standard DP turbine with its totally-enclosed hydraulic governing system.

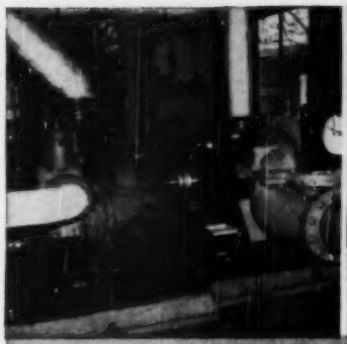
This pressure-relayed system gives you ease and accuracy of control that compares with the precision speed governing of large central station turbines. Yet the DP is a standard design, sold at standard prices.

YOU GET A WIDE SPEED RANGE—30% adjustment for flexibility of operation. This feature, combined with the wide variety of ratings and speeds available, provides you with the "right" turbine for any job.

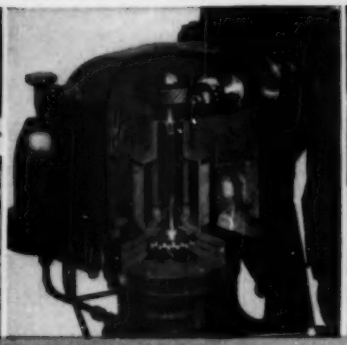
YOU GET PERFORMANCE ACCURACY—6% regulation means holding the speed you want on important processes. Regulator control is available for governing in terms of any process requirement.

YOU GET GREATER RELIABILITY—the hydraulic governing system keeps moving parts to a minimum, operates in an oil atmosphere with no exposed linkages. This eliminates wear and corrosion, assures dependable operation.

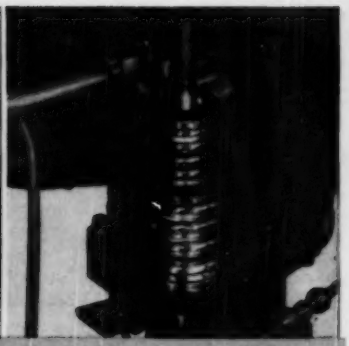
Check the features of the standard DP. It can give you the kind of precision performance you're looking for, the savings in operating costs that boost profits. Contact your nearest G-E sales office, or write for bulletin GEA-4955A. Apparatus Dept., General Electric Co., Schenectady 5, N. Y.



In this plant, a General Electric 30-hp DP turbine is coupled to a centrifugal pump. The hydraulic governing system provides accurate, reliable performance over a wide range of speed adjustment.

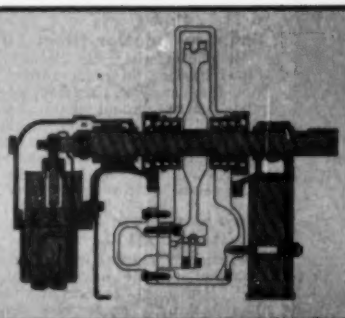


This turbine-type oil pump, gear driven from the main shaft, signals any tendency for the DP to speed up or slow down with changes in load. The pump also provides oil pressure for positioning the governor valve.



Acting on the speed signal from the oil pump, this pressure relay controls the amount of oil pressure in the operating cylinder. This cylinder regulates the amount of steam admitted to the turbine through the governing valve.

HYDRAULIC GOVERNING makes a difference



Here's What Standardization Provides For You

In the diagram at the left, all shaded parts are interchangeable on all sizes of DP turbines. Thus, it is easy to stock spares, and maintenance costs are reduced. All models have standard shaft height and coupling fits for easy installation or re-location in your plant. Standardization cuts manufacturing expense and the savings are passed on to you in the form of extra features usually found only on "special" turbines.

GENERAL ELECTRIC

and Mallinckrodt Streets, St. Louis 7, referring by number to this PETROLEUM REFINER item.

Process Plants (Item 98)

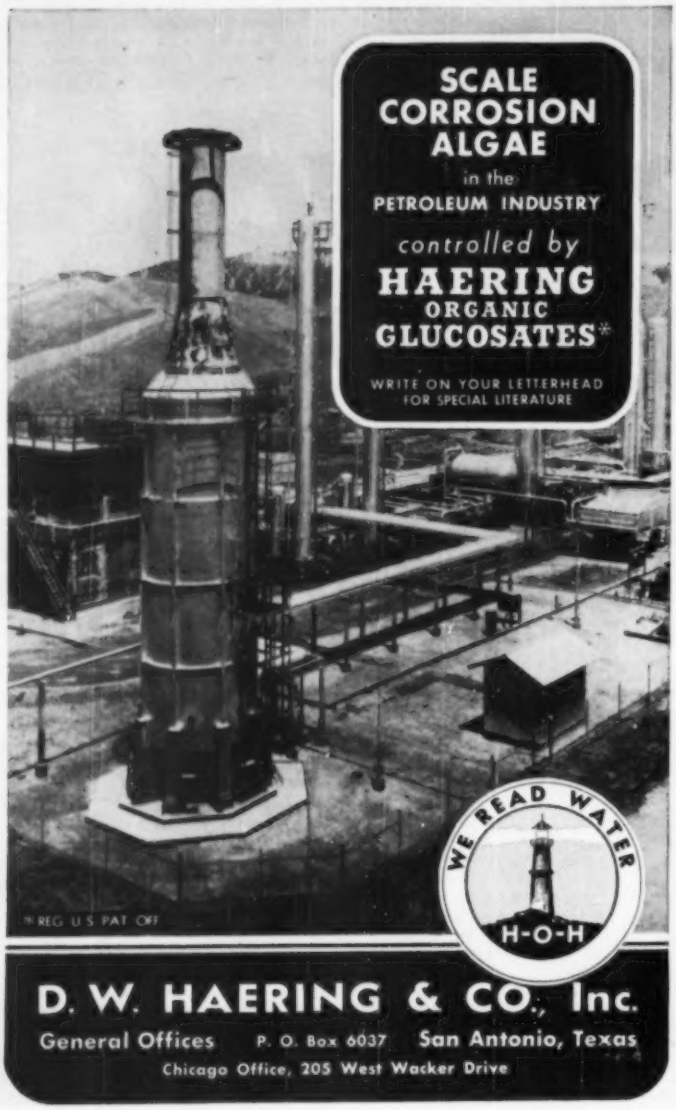
The I-P-E robotization system, an engineering application of standard control instruments and electric, electronic and pneumatic inter-locks, which system accomplishes all necessary production and control operations, is announced by Industrial Process Engineers. Robotization is "equally applicable to existing as well as proposed plants, whether batch or continuous."

For literature write Industrial Process Engineers, Newark, N. J., referring by number to this PETROLEUM REFINER item.

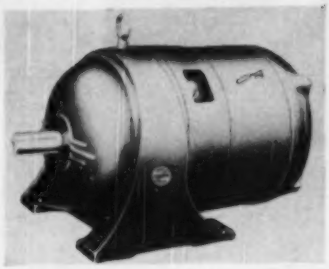
Steel Chart (Item 99)

Working characteristics of steels in temperatures from —300° F. to 2900° F. are shown in Tempil° Corporation's plastic laminated wall chart which also defines temperature zones including hot-working, annealing, normalizing stress relieving, carburizing and prekeating for welding. A diagram symbolizing the change in grain size with temperature, and 23 defined fundamental metallurgical terms are also given.

For a copy industrial executives may write Tempil° Corporation, 132 West 22nd Street, New York 11, referring by number to this PETROLEUM REFINER item.



Gearmotors (Item 100)



Foote Bros. Gear and Machine Corporation and The Louis Allis Company have announced a complete line of gearmotors that use the hard helical gears and other moving parts which have been processed and heat treated under new and improved methods of manufacturing control. Manufactured in 17 sizes, the gearmotor provides single, double and triple reduction units having output speeds from 780 down to 7.5 rpm. Integral ratings from 1 thru 75 hp. are available. A selection of motor enclosures includes the conventional open drip-proof, splash-proof, totally enclosed and explosion-proof construction.

For further information write either Foote Bros. Gear and Machine Corporation, 4545 S. Western, Chicago or Louis Allis Company, 427 E. Stewart Street, Milwaukee 7, Wisc., referring by number to this PETROLEUM REFINER item.

Unit Heaters (Item 101)

Features, construction, capacities, specifications, and principles of operation are given for four types of Black, Sivalls & Bryson, Inc.'s unit heaters, described in part 3, section 3 of Catalog 54. Uses for multi-unit treating systems, and special applications are given for the volume type heater, internal firebox heater, vertical fluid jacket heater, and horizontal fluid jacket heater. Multi-treating systems include forced flow, fresh water circulating, true thermo-siphon, and gas jet circulating. Special applications include heating stock tanks, "glycol type" dehydration plants, gas sweetening plants, steam generation, and batch treating.

For further information write Black, Sivalls & Bryson, Inc., Kansas City, Mo., or Oklahoma City, referring by number to this PETROLEUM REFINER item.

Chemical Injector (Item 102)

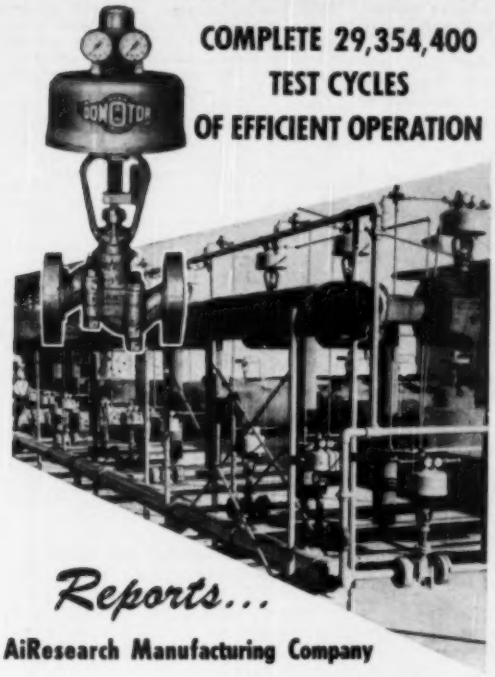
Bulletin describing the chemical injector of McFarland Manufacturing Corporation (January PR, page 190) gives complete description and specifications of the patented fluid control instrument.

For a copy write McFarland Manufacturing Corporation, 1630 Roberts Street, Houston 3, referring by number to this PETROLEUM REFINER item.

Pipe Line Shock Absorber (Item 103)

A cushion, encased in a spherical metal chamber, plus no moving metal parts in R-S Products Corporation's new pipe line shock absorber, sectional view shown, help to eliminate shock and hammering in pipe lines and liquid systems, according to the manufacturer. Three of the five models, designated as the Industrial, Dual and Super, are adapted for general industrial use. The absorber can be in-

ANNIN DOMOTOR VALVES



COMPLETE 29,354,400 TEST CYCLES OF EFFICIENT OPERATION

Reports...

AiResearch Manufacturing Company

The service record of 40 single-seated Annin Domotor Valves installed at AiResearch Manufacturing Company, well illustrates the efficiency and dependability of these valves under severe operating conditions.

Installed July, 1948, in a turbine test station to carry air at 100 psi and 1000° F., these valves have to date completed approximately 29,354,400 test cycles of continuous, trouble-free operation. Since their installation, none of the valves have required major overhaul. They were serviced *while in the line* . . . an exclusive feature provided by the separable valve body construction of Annin Domotor Valves.

The history of these valves is typical of Annin Domotor Valve installations all over the country. They all tell the same story . . . . of Annin Domotor Valve maintenance economy, positive control and long, dependable service.

Write today for this bulletin.
A new bulletin showing installation and operating features of the Domotor Valve will be sent to you upon request.

THE ANNIN COMPANY
3500 Union Pacific Avenue
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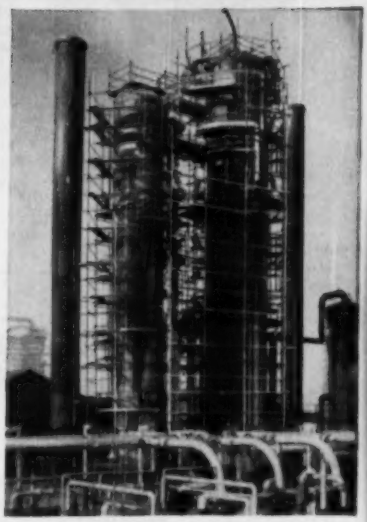
Investigate ANNIN DOMOTOR VALVES *Valves*

TUBELOX STEEL SCAFFOLDING

SOLVES REFINERS' PROBLEMS

ONLY FOUR BASIC PARTS REQUIRED



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Versatile!

- No job too difficult
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Economical!

- Only 4 basic parts
- Easy to erect and take down — even in restricted space
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- Interlocking steel tubes
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See Your Classified Telephone Directory for Nearest Office

stalled in any position.

For further information write R-S Products Corporation, Wayne Junction, Philadelphia 44, referring by number to this PETROLEUM REFINER item.

Safety Messages (Item 104)

Safety messages which gain and hold attention by a combination of light and motion are made possible by the new flash-o-graph, a product of Mine Safety Appliances Company. Messages are spelled out in bright dots of light which move along continuously like electric news bulletins. The unit is cased in steel with a black crackle finish. It measures 23x3x6" and weighs 6½ pounds complete. Fifty-two standard tape messages are available and special messages can be furnished on request.

For a bulletin write Mine Safety Appliances Company, Braddock, Thomas and Meade Streets, Pittsburgh 8, referring by number to this PETROLEUM REFINER item.

Thermowells (Item 105)

Featuring special metal coverings of tantalum, colmony, lead and stellite for thermowells, that are particularly adapted for specific requirements of abrasion, corrosion and erosion, Catalog No. 200 of Trinity Equipment Corporation describes basic types of thermowells, their variations and other special process industry equipment. Special fabricated products including pressure vessels and laboratory apparatus also are shown.

For a copy write Trinity Equipment Corporation, 468 Westfield Avenue, East, Roselle Park, N. J., referring by number to this PETROLEUM REFINER item.

Leak Detector (Item 106)

Consolidated Engineering Corporation's Leak Detector Bulletin describes applications and leak detection methods used in both vacuum and pressure systems. Examples of both Probe and Envelope techniques are discussed and schematic diagrams show the necessary testing equipment.

For a copy write Consolidated Engineering Corporation, 620 N. Lake Avenue, Pasadena 4, Calif., referring by number to this PETROLEUM REFINER item.

Drain Lines and Fans (Item 107)

The Duriron Company, Inc.'s list H-2 illustrates all company acid proof equipment for handling corrosive wastes from chemical laboratories, engraving shops, chemical plants, plating rooms, and steel mills. The list contains new items and items of improved construction.

Also available is Bulletin 1103 which describes corrosion resisting fans made of parts cast in Duriron, Durichlor or Durimet 20. The fans are built in five sizes with capacities up to 7500 cfm.

For this literature write The Duriron Company, Inc., Dayton 1, Ohio, referring by number to this PETROLEUM REFINER item.

Combustion (Item 108)

"Combustion Control" (Technical Bulletin No. 103.) prepared by General Power Plant Corporation, contains an exposition of the nature of haze and its use as a combustion index. A description of devices ranging from the simplest auxiliary controls up to complete robot-eye installations is included along with a discussion of methods of control for all hydro-carbon fuels.

For a copy write General Power Plant Corporation, 381 Fourth Avenue, New York 16, referring by number to this PETROLEUM REFINER item.

Viscosity Control (Item 109)

Brookfield Engineering Laboratories, Inc.'s "viscotrol" can be supplied to control any working viscosity from 2 to 50,000 centipoises with the instrument able to respond to any viscosity change

Think FIRST of the coating that LASTS

"... as for maintenance—there has been none and we do not look for any ..."

"... we have been very well pleased with the use of Insul-Mastic for coating tanks and have adopted it as standard for tanks in places where condensation and corrosion occur so badly as to nullify the use of ordinary paints."

These excerpts from letters we did not request give an indication of what Insul-Mastic Protective Coatings can do for your plant. Long life, even under badly corrosive conditions, is one of its features most praised by industry.

Why not learn from our engineers how Insul-Mastic can save your money and equipment by barring the corrosive forces of acids and liquors. Write Department 3 at the address below.

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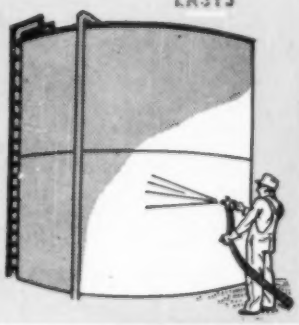
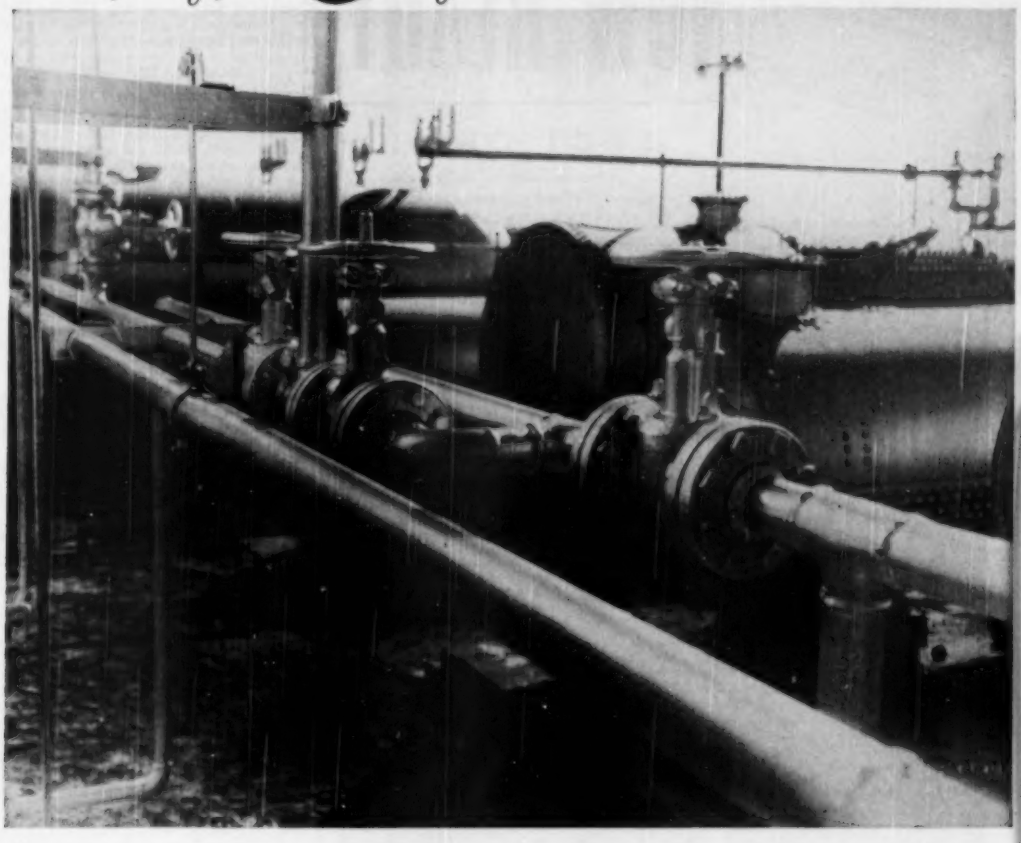


Insul-Mastic Corporation
OF AMERICA
OLIVER BUILDING • PITTSBURGH 22 PENNSYLVANIA

Specify ORBIT VALVES *for* **YOUR GASOLINE PLANT**



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WITH ORBIT FORGED STEEL VALVES

When planning new construction, modernization or expansion programs, specify **ORBIT VALVES** for: Tank Car and Truck Loading Racks, Butane and Propane Storage Tanks, Dehydration Units, Caustic Treaters, Alumina Dryers, Compressor Discharge Lines, Accumulators, Loading Rack Pumps, Butane and Propane Vapors. There are also many other installations in a plant where **ORBIT VALVES** can be used to advantage. We will be glad to make other recommendations.

Valves shown above on Caustic Treater are **ORBIT** Figure Number TF201-3, Two Inch 300 lb. Stainless Steel Trimmed, Forged Stel Intermediate Temperature, 600 lb. W.P. @ 100° Fahr., Maximum Rated Temperature 375° Fahr. Orbit Forged Steel Valves can be furnished with *Stainless Steel* Trim or *Carbon Steel* Trim.

*Orbit is a trade mark.

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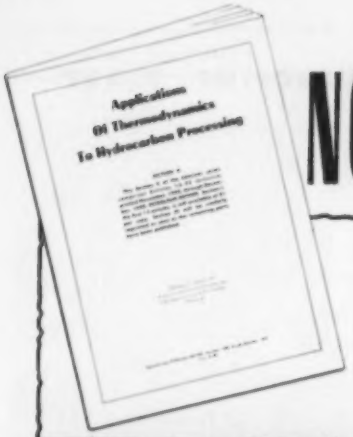
BRANCHES:

Casper, Wyoming—The Great Western Co. (serving the Rocky Mountains and Canada)



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within 1 percent of the particular value for which it is set. The unit can be engineered into production systems to provide continuous and automatic viscosity control.

For a copy of data sheet 012 write Brookfield Engineering Laboratories, Inc., Stoughton, Mass., referring by number to this PETROLEUM REFINER item.

Graphic Panels (Item 110)

A 25-foot graphic panel, containing 73 nullmatic controllers for crude and vacuum units, fluid cat crackers, fractionation units, gas concentration, poly, and LPG units is described in Bulletin 509 of Moore Products Company. This panel, pictured in October's PR, page 130, provides centralized control for Rock Island Refining Corporation's Indianapolis refinery. Also explained with accompanying pictures is pneumatic force balance for measurement, transmission, and control. Standard transmitters and controllers are shown including flow meters, thermometers, pressure controllers liquid-level and differential transmitters.

For a copy write Moore Products Company, H & Lycoming Streets, Philadelphia 24, referring by number to this PETROLEUM REFINER item.

Valve Specialties (Item 111)

Davis Regulator Company's valve specialties, pressure, flow and liquid level controls for steam, air, gas, water, oil and other fluids are described in Catalog A 50 which contains six condensed bulletins and one technical data sheet. Described are pressure regulators, altitude valve, pump governors and strainers; lever, float and motor operated valves, pilot valves; back pressure, relief and non-return valves, steam trap and air vent; liquid level controllers; solenoid valves; dia-ball unit and applications; and capacity charts.

For a copy write Davis Regulator Company, 2541 South Milwaukee Avenue, Chicago, referring by number to this PETROLEUM REFINER item.

Industrial Thermometer (Item 112)

Data on liquid-in-glass industrial thermometers are presented in tabular and sectionalized form in Precision Thermometer and Instrument Company's Bulletin E. All basic models, sizes, forms, and attachments with simplified application data to enable the user to select the proper thermometer for any industrial installation are shown. The bulletin incorporates necessary information for both engineering and purchasing departments.

For a copy write Precision Thermometer and Instrument Company, 1470 Brandywine Street, Philadelphia 30, referring by number to this PETROLEUM REFINER item.

Chemical Feeder (Item 113)

Fischer & Porter Company's Catalog 62 describes a new compact, self-contained chemical feeder, the "Feed-Rator," made of transparent acrylic plastic and measuring 10 by 2 inches. This unit will simultaneously control, meter and dispense relatively small amounts of cata-

lysts, disinfectants, inhibitors, reagents and other chemicals into a larger stream. The built-in eductor takes the place of a pump, and therefore many highly corrosive chemicals can be fed directly from a container. The unit will treat up to 7000 gallons per day of water directly. In a bypass arrangement, using a solution containing 5 percent active reagent by weight, five parts per million of the reagent can be delivered to over 14 million gallons of water per day.

For a copy write Fischer & Porter Company, Hatboro, Pa., referring by number to this PETROLEUM REFINER item.

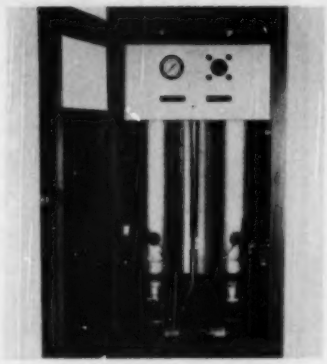
Turbines (Item 114)

The multi-stage turbine catalog of De Laval Steam Turbine Company includes a discussion of the economics of by-product power, as well as diagrammatic sketches showing the utilization of heat for various typical plant operating conditions. Pointing out the flexibility of turbine drive, the catalog shows the basic types of De Laval turbines for different operating conditions and applications up to 20,000 hp. Design features of other company turbines are pictured as are helical gears for applications where geared turbine driven equipment is used.

For a copy write De Laval Steam Turbine Company, Trenton 2, N. J., referring by number to this PETROLEUM REFINER item.

Dynamic Humidifier (Item 115)

Continuous drying of 50 scfm. of air at 100 psig. and 70° F. to a maximum dew-point of —40° F. is claimed for Industrol Corporations Model 50 EIAC dynamic humidifier. These units are primarily designed for industrial instrument air supply, for the purpose of reducing maintenance on this type of equipment. The units eliminate the forming of condensate in the air lines and the possibility of the freezing up of those lines located out-of-doors. A 110-volt 60 cycle line current operates the unit, which is completely automatic in its operation. The cabinet dimensions are 22 inches wide, 18 inches deep and 43 inches high, for floor or table mounting, with all piping and electrical connections terminating at the bottom back of the cabinet.



New Equipment

For Bulletin DD-110, available shortly, write Industrol Corporation, 88-35 76th Avenue, Glendale, Brooklyn 27, referring by number to this PETROLEUM REFINER item.

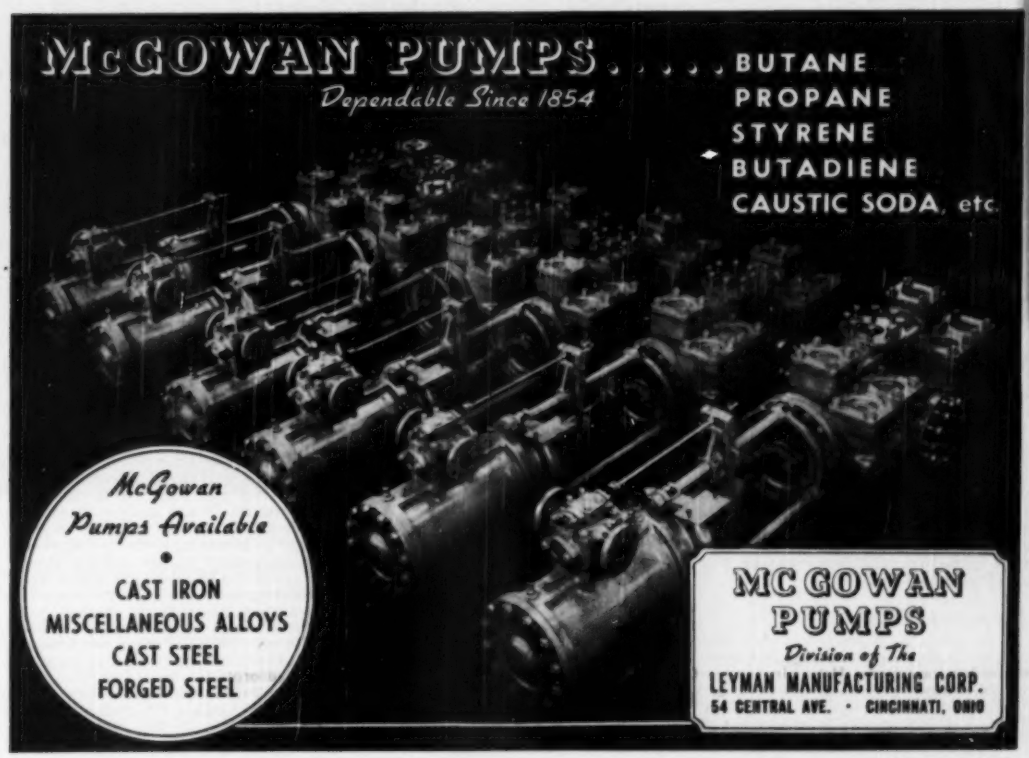
Manometers (Item 116)

Minimum mercury contamination and easy cleanout are among the features of a line of reservoir-type manometers announced by King Engineering Corporation. Available in 14 lengths with scales from 12 to 116 inches long, for use in line pressures up to 200 psi., these manometers can be mounted flush; flat on front of panel; on a wall; or on a bench or table with tripod mounting. The reservoir and connecting parts are steel, brass, or stainless steel. Specifications are given in Bulletin M-101.

For a copy write King Engineering Corporation, Box 100, Ann Arbor, Mich., referring by number to this PETROLEUM REFINER item.

Protective Snubber (Item 117)

Action of Parker Appliance Company's gauge snubber in protecting gauges from line shock and vibration while eliminating needle fluctuation for more accurate readings is described in Bulletin 380. Thirteen steps of adjustment are available by use of three snubbing pins in a side-opening chamber out of the line of flow. Made of forged stainless steel or forged brass, the snubber is available with ¼ or ½ inch internal



pipe thread connections, for service at working pressures up to 5000 psi.

For a copy write The Parker Appliance Company, 17325 Euclid Avenue, Cleveland 12, Ohio, referring by number to this PETROLEUM REFINER item.

Fluid Drive (Item 118)

Link-Belt Company is offering a catalog and engineering data book which describes how the original "Ed" type electrofluid drive has been applied to a large variety of applications and is now available in sizes up to 30 hp. The book also shows that the line has been expanded typewise. In addition to the motorized type "Ed" there is now the Gearmotor type "EG" and types "Ed" and "FG" units, which are the equivalents of the "ED" and "EG" with exception that input shafts are supplied in place of integral motors. Fluid drive arrangement for applications as high as 200 hp. are shown. Other sections of the book contain types, sizes, arrangements and dimensions of units available; features of construction; advantages; selection tables; typical examples of fluid drive selections; and photographs of actual installations.

For a copy write Link-Belt Company,, 307 N. Michigan Avenue, Chicago 1, referring by number to this PETROLEUM REFINER item.

Heat Loss Data (Item 119)

A bulletin by the Thermobloc Division of Prat-Daniel Corporation provides data tables for computing heat loss and figuring heat requirement. Also included are tables on outdoor design temperatures, common types of industrial construction, heat losses through window and door infiltration and a table on heating constants. Descriptions of self-contained, direct-fired industrial heating units of 300,000 and 550,000-btu.-per-hour-output capacity are presented. Also available are a series of data sheets showing how direct fired heaters can be used for tempering make-up air, process heating, and other special applications.

For copies of the bulletin and data sheet series (Data File 901) write the Thermobloc Division of Prat-Daniel Corporation, East Port Chester, Conn.

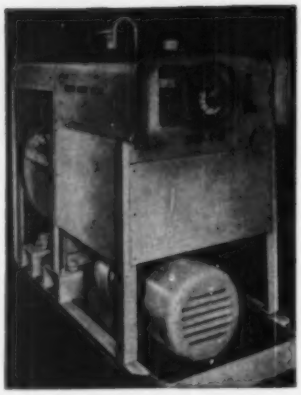
Condensers (Item 120)

Bulletins of Condenser Service & Engineering Company, Inc., are available as follows: automatic steam generators, Bulletin G-491; steam jet air ejectors, for air removal from condensers; lube oil and jacket water coolers; centrifugal and piston pumps; and condensers, Bulletin 441-C.

For copies write Condenser Service & Engineering Company, Inc., Seaboard Trust Building, Hoboken, N. J., referring by number to this PETROLEUM REFINER item.

Arc Welder (Item 121)

The 200-amp. Hornet "Special" arc welder, combining a compact 36A generator with a four-cylinder, 31-hp., air-cooled Wisconsin engine, has been developed by Air Reduction Sales Company. The 36A generator, which has a welding range from 40 amperes at 20



volts to 250 amperes at 40 volts, features "efficient operation, simplified current control, self-contained exciter; and convenient terminals." The air-cooled engine has magneto ignition with impulse starting. Hand cranking eliminates battery maintenance. The steel core vee-belt coupling permits economic running of both generator and engine at economic speeds.

For further information write Air Reduction Sales Company, 60 East 42nd Street, New York 17, referring by number to this PETROLEUM REFINER item.

Pumps (Item 122)

Central Engineering & Supply Company's Catalog Section 5 describes the company's line of motors, pumps, and starters. Included are single and three-phase motors; switches, starters and relays; Westco pumps; repair parts; rotary, paddle type, and Weinman centrifugal pumps.

For a copy write Central Engineering & Supply Company, 1925 Cedar Springs Road, Dallas 1, referring by number to this PETROLEUM REFINER item.

Control Centers (Item 123)

New standardized control centers for plant electric power circuits are described in Booklet B-4213, available from Westinghouse Electric Corporation. Discussed are safety features, including the plug-in type disconnects on the line side, the complete baffling of starter units for added safety in keeping possible faults localized, and the design which permits compartment doors to be closed after the units have been removed, preventing personnel from coming in contact with the live bus.

For a copy write Westinghouse Electric Corporation, P. O. Box 2099, Pittsburgh 30, referring by number to this PETROLEUM REFINER item.

Lab Appliances (Item 124)

Castaloy laboratory appliances are described in Fisher Scientific Company's bulletin as follows: Burette holders, and supports; utility, extension, and burette clamps; flexaframe supports and accessories; special holding clamps; clamp holders; special purpose supports; and devices for controlling flow.

For a copy write Fisher Scientific Company, 717 Forbes Street, Pittsburgh 19, referring by number to this PETROLEUM REFINER item.

Magnesium Anodes (Item 125)

How magnesium helps to stop corrosion is explained in a Dowell Incorporated booklet which explains the metal's useful properties in cathodic protection of pipe lines, gathering lines, tank bottoms, sea water corrosion, lead sheath cables, heat exchangers, and tower footings. Discussed are the design of a magnesium anode installation, current required for cathodic protection, how many anodes will be needed, which magnesium anode should be used, where the anodes should be located, how they're installed, and the importance of backfill.

For a copy write Dowell Incorporated, Tulsa 3, referring by number to this PETROLEUM REFINER item.

Strain Gauges (Item 126)

How to apply SR-4® strain gauges and how to select and use SR-4 bonded resistance wire strain gauges in stress analysis is described in two bulletins of The Baldwin Locomotive Works. Bulletin No. 279-A, on SR-4® gauges for stress analysis, explains the fundamentals of both simple and practical strain gage circuits and instruments. A section on calculation of gauge output gives derivations of formulas for computing dynamic circuits and Wheatstone bridge circuits, and includes examples of these computations. Bulletin 279-B, How to Apply SR-4® strain gauges, gives detailed procedures for attaching SR-4® resistance wire strain gauges to surfaces.

For copies write The Baldwin Locomotive Works, Philadelphia 42, referring by number to this PETROLEUM REFINER item.

Jacketed Valves (Item 127)

To overcome the disadvantages of other methods of heating valves handling fluids that solidify or are difficult to move at room temperature, Alloy Steel Products Company, Inc., has developed corrosion-resistant, jacketed gate and globe valves. Bulletin No. 3 describes these valves, which range from 1 to 4 inches with 2 to 6-inch flanges. No. 1105 valve has rising stem with stationary handwheel. No. 1305 has rising stem and handwheel. No. 1505 jacketed check valve has bolted cover with globe type check.

For a copy write Alloy Steel Products Company, Inc., Linden, N. J., referring by number to this PETROLEUM REFINER item.

Gas Analyses (Item 128)

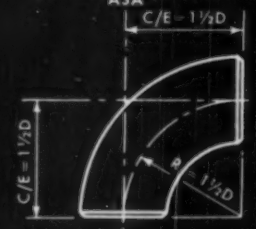
"The Analysis of Gases, A Brief History and Modern Trends" by L. V. Guild of Burrell Corporation is the featured article in the corporation's "Fall Announcer." Material gives historical background and major developments in the progress of gas analysis from Von Helmont's work in the 16th century until the present time. Also discussed is measurement of physical and chemical properties of gases and major fields of measurement are listed with a short description of methods involved, etc. Title headings of this section are thermal conductivity, infrared spectroscopy, mass spectroscopy, low temperature distillation and fractional adsorption.

For a copy write Burrell Corporation, 1942 Fifth Avenue, Pittsburgh 19, referring by number to this PETROLEUM REFINER item.

Improvements and economies in welded piping result from this *Variety* of MIDWEST ELBOWS

1

LONG RADIUS ASA

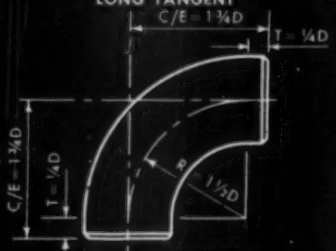


SIZES: ¾" TO 24", INCLUSIVE

Dimensions conform to applicable size range of American Standard for Butt-Welding Fittings, ASA B16.9. Radius and center-to-end dimension equal 1½ times nominal pipe size.

2

LONG RADIUS LONG TANGENT

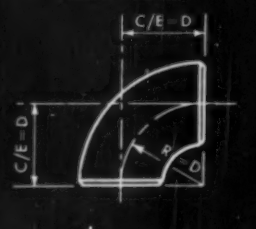


SIZES: 2" TO 20", INCLUSIVE

Same radius as ASA Elbows but with long integral tangent on each end — an exclusive Midwest feature that saves time and pipe. No price increase over ASA Elbows.

3

SHORT RADIUS

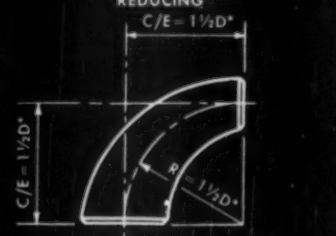


SIZES: 1" TO 30", INCLUSIVE

Where space limitations prevent use of ASA Elbows or Midwest "Long Tangent" Elbows shown above at right, these short turn elbows without tangents are recommended.

4

LONG RADIUS REDUCING



SIZES: 2" TO 12"*, INCLUSIVE

Midwest Reducing Elbow takes the place of a straight elbow and a reducer. It saves more than one-third of the welding and improves both design and appearance.

SYMBOLS C/E—Center-to-End Dimension; T—Length of Tangent; D—Nominal Pipe Size; R—Radius; *D—Dimension is for larger Pipe Size

MIDWEST WELDING FITTINGS Improve Piping Designs and Reduce Costs

90° ELBOWS

REDUCING 90° ELBOWS — 45° ELBOWS

LAP-JOINT STUB ENDS — REDUCERS

CAPS — SADDLES — SLEEVES

RETURN BENDS — TEES

LATERALS — CROSSES

REDUCING-ON-RUN TEES

SHAPED NIPPLES — FLANGES

The *variety* of Midwest Welding Elbows is particularly important because of the exceptional latitude in design and economy in erection that it provides. For example, the Midwest Long Tangent Elbow permits faster, easier, more accurate lining up with pipe . . . removes weld from point of maximum bending stress . . . often eliminates a short nipple and its extra weld. Slip-on flanges are easily used with minimum change in flange and fitting.

This "Variety" is only one of several reasons why many users prefer Midwest Welding Elbows.

Only MIDWEST offers this VARIETY

MIDWEST PIPING & SUPPLY CO., Inc.

Main Offices: 1450 South Second Street, St. Louis (4), Mo.

Sales Offices: New York (7), 30 Church St.

Chicago (3), 79 West Monroe St. • Los Angeles (33), 520 Anderson St. • Houston (2), 229 Shell Bldg. • Tulsa (3), 533 Mayo Bldg. South Boston (27), 426 First St. • Distributors in Principal Cities

About EQUIPMENT and SERVICE Suppliers

Consolidated Western Completing Steel Shop

Light and heavy plate fabricated mild steel, stainless steel and nickel-clad vessels principally intended for the Gulf Coast's petroleum refinery and chemical industries is to be the output of Consolidated Western Steel Corporation's new steel plate fabricating shop scheduled for full operation by March 1 at Orange, Texas. The new pipe mill, to open March 15, and the plate mills, are a major part of the expansion program begun following purchase of the Orange wartime shipyard from the government in November.

Part of the plate mill is already in operation with a considerable amount of plate fabrication being turned out, according to H. C. Cranfill, vice president, in charge of administration for the U. S. Steel subsidiary plant. Several units of plate shop machinery and equipment are being assembled and installed at the shop.

The pipe mill is geared for producing 50 miles of 24-inch diameter and larger electric welded and expanded pipe a month. First production of the mill will be 31-foot lengths of 30-inch pipe.

Conversion of the shipyard properties, located adjacent to Consolidated Western Steel Corporation's present structural steel fabricating plant, into additional fabricating facilities is ahead of schedule, according to the corporation, despite unseasonably heavy rains during December.

Heads Darcoid Company of Texas

In charge of the Houston office of Darcoid Company of Texas is Thomas W. Rosenstein, formerly a representative of the L K Pump Valve Company in this territory.

Rosenstein

The former company whose office is at 1698 Indeborg Street, offers a line of mechanical packing for the chemical and refinery industry. It handles the products of Darcoid Company of New York. Territory of the Texas company includes Oklahoma with particular emphasis on the refinery and chemical industry on the Texas Gulf Coast.

District Changes Announced By Republic Supply Company

Republic Supply Company has announced personnel and organizational changes as follows: District No. 2, formerly the Texas and Louisiana Gulf Coast area, has been divided into three parts. H. C. Kinney, Houston manager of the district, now has headquarters in San Antonio with territories including Corpus Christi, Alice, Hebbronville, McAllen, Pleasanton, Falfurrias and Victoria. Houston and surrounding trade territory has become the Houston district sales office under management of Ralph B. Harp.

New Iberia and Lake Charles, La., stores, formerly a part of District 2, are now supervised by W. M. Haynes, who is also manager of refinery and industrial sales for the home office. The newly created Repsco Seal Division, Industrial Sales Department, manufacturer of the rotary shaft seal, is headed by Frank Sparks.

C. I. Crais Company Opens New Alabama Sales Offices

C. I. Crais Company, sales representative for Lukens Steel Company and its divisions, By-Products Steel Company and Lukenweld at Coatesville, Pa., since 1947, offices in the Industries Building, New Orleans, has moved to Birmingham, Ala., where it will open offices at 529 American Life Building. In its new location C. I. Crais Company will serve Lukens, By-Products and Lukenweld customers in Arkansas, Florida, Georgia, Louisiana, Mississippi and South Carolina. Florida, Georgia and South Carolina heretofore have been served by Lukens Baltimore sales office.

Monsanto Executive Joins Petrochemical Sales Staff

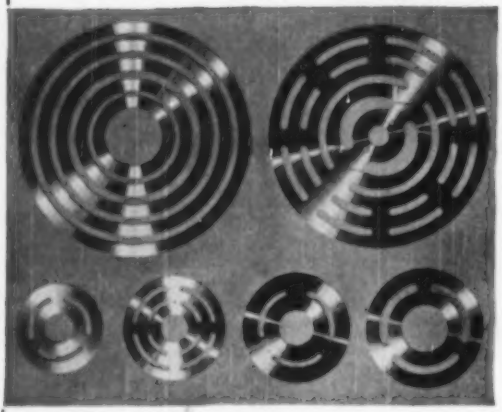
Assistant to the president of Monsanto Chemical Company since 1948, James B. Irwin, Jr., has been named a member of the petroleum chemical sales department of the organic chemicals division. He has been with the company since 1940. In 1942, Irwin was transferred from the Monsanto, Ill., plant to the Longhorn ordnance works operated by Monsanto for the government at Marshall, Texas, where he was assistant area supervisor. He has also been a member of the plant's development department and supervisor of the chlorine department at Monsanto, Ill. Irwin received a B. S. degree from Princeton University in 1940 and an M. S. from Washington University in chemical engineering in 1948.

Worthington Engine Division Gets New Eastern Manager

The appointment of A. M. Boehm as eastern manager, Engine Division, has been announced by Worthington Pump and Machinery Corporation. Boehm will handle sales negotiations for gas and oil pipe lines equipment and oil and gas engines for all services, and will continue to make the corporation's New York district office his headquarters.

Boehm has served the company for 25 years as engine sales specialist assigned to district offices throughout the coun-

Voss VALVE PLATES and DISCS FOR COMPRESSORS



ANY DESIGN • ANY SIZE • INDIVIDUALLY CUT AND GROUND

MACHINED—*not punched out*—which prevents cracks and strains thus eliminating breakage risk of fragments of broken plates getting in cylinders. Best obtainable alloy steels used to meet requirements. Oil hardened and tempered to correct hardness. Precision ground to perfect flatness.

Let VOSS make your next Valve Plates and Discs!

J. H. H. VOSS CO., Inc. 785 East 144th Street NEW YORK 54, N. Y.

try. He succeeds W. L. Russell who has been assigned to handle Canadian sales for John Inglis Company, Worthington's Canadian associate.

Amstutz

Link

Oil Well Supply Names Two to Executive Posts

Fred E. Link, general works manager for Oil Well Supply Company, U. S. Steel subsidiary, has been named to the new post of assistant to president, headquarters remaining at home offices in Dallas. Link will study and develope programs for facilities improvement to provide economies in manufacturing and distribution. Gordon M. Amstutz, chief industrial engineer for the past year, succeeds Link as general works manager. Amstutz has temporary headquarters at the company's Imperial Works at Oil City, Pa.

Joining "Oilwell" in January, 1946, Link has served as assistant to vice president, handling special industrial engineering assignments, assistant to president, in charge manufacturing department, which title was later changed to general works manager. He was graduated from Notre Dame in 1926 with a B. S. degree in mechanical engineering. He has been employed with J. A. Utley Construction Company, General Motors' Fisher Body Division, and Campbell-Ewald, Inc., and for two years was a private consulting engineer and chief industrial engineer for North American Aviation's aircraft factory at Dallas from 1941-1945.

Amstutz began as chief industrial engineer with Oil Well in 1949. He received a B. S. degree in electrical engineering from Ohio State University in 1927. First as a time study engineer with B. F. Goodrich Company at Akron and as an industrial engineer for Reliance Electric and Engineering Company of Cleveland, he later joined Armstrong Cork Company in 1934. Since 1946 Amstutz has been director of production for Denison Engineering Company of Columbus, Ohio, until his appointment as chief industrial engineer for Oil Well.

Graver Tank Steel Manager

Graver Tank & Manufacturing Company, Inc., East Chicago, Ind., has appointed Harry A. Dennis manager of sales for the company's stainless and alloy steels division. He will also continue his present assignment as manager of Weldment sales. Dennis was formerly assistant district manager of sales for Lukens Steel Company and their By-Products and Lukenweld divisions.

Duriron Personnel Changes

Wayne D. Staley, formerly New York district manager for The Duriron Company, appointed general sales manager,

He didn't forget . . .

He just took a chance!

When workers risk their eyes, with disastrous results to both themselves and the company alike, it's time to look into the cause of unsafe practices.

Goggle Style TAW51

WILLSON answers the problem of getting safety equipment worn by designing the utmost comfort into their entire line of eye and respiratory protective devices. The goggles illustrated have eyecups that are molded to fit the bony structure around the eyes. The chain bridge and elastic headband are adjustable for comfortable fit. And the Super-Tough* lenses meet or exceed Federal Specifications for optical clarity as well as impact resistance.

NEW CATALOG

In addition to product information, it contains information on safety glass, filter glass, respiratory hazards, etc., which will help you select proper safety equipment to meet specific hazards. Send for it!

WILLSON

"Established 1870"

*T. M. Reg. U. S. Pat. Office

WILLSON PRODUCTS, INC., 246 WASHINGTON STREET, READING, PENNA.

A watchful finger on the pulse of the process...

that's your PALMER THERMOMETER

Where precise process temperatures are vital, put Palmer Thermometers on guard. Palmer instruments are guaranteed permanently . . . can't fail you at critical moments.

Palmer "Red-Reading-Mercury" turns the pure, silvery mercury into an easily seen, wide red column . . . your temperature readings are certain to be accurate. Full length graduated scale. Large, clear markings.

Ruggedly built...Palmer Thermometers are housed in extruded brass cases, chrome finished. Double-strength glass shield, snug fitting with patented spring tension. Snap-on cap that's removable, but won't work loose.

For full details, write for catalog.

Mfrs. of Industrial, Laboratory, Recording and Dial Thermometers.
2515 Norwood Ave., Cincinnati 12, Ohio
CANADIAN PLANT: King & George Sts., Toronto, 2

PALMER THERMOMETERS INC.

will be located at the home office in Dayton, Ohio. In directing sales and advertising activities, he will replace D. E. Jack, who has resigned as vice president in charge of engineering and sales. R. F. Sharpe, former manager of the Philadelphia office, has been appointed New York district manager. Ralph L. Watts, former sales engineer in New York, will be in charge of the Philadelphia office.

Dowell Transfers Engineers To Texas District Offices

John S. (Jack) Talbot, development engineer for Dowell Incorporated in Alice, Texas, has been promoted to district sales engineer with the Houston area district office. Tom J. Tighe, service engineer at Houma, La., has been promoted to sales engineer at Victoria, Texas, and Joe P. Moran, Victoria sales engineer, to Alice.

Talbot

Talbot, a University of Oklahoma graduate in petroleum engineering, went to Alice in 1947 as development engineer. Before coming to Dowell, in 1946, Talbot was associated with Champion Refining Company, at Enid, Okla.

Tighe, a graduate of Texas A. & M. College, started with Dowell as a service engineer in Lafayette, La., in June, 1948. Moran has been in Victoria since 1949, having transferred there from Grayville, Ill., and El Reno, Okla., in 1947. Moran received a bachelor of engineering in mining at Ohio State University.

Honeywell Moves Into New St. Louis Branch Building

The St. Louis branch of Minneapolis-Honeywell Regulator Company and its Brown Instruments Division have moved into a new office building at 4354 Olive Street. The first to be built and owned by the company, the building, costing approximately $90,000, contains about 6600 square feet of floor space. Provision has been made for a future second floor over the front portion of the building. Besides the office space, the building provides a conference room, drafting room, instrument repair, stationery supply, coat room and a coffee room for employes. The main lobby also contains facilities for the sale of service parts.

B. C. Simmons is branch manager.

Saval, Inc., Forms Valve Firm

"Shear-Seal" valves for industrial applications will now be made by Saval, Inc.'s newly formed company known as Barksdale Valves. The parent company, formerly maker of the valves, will devote facilities exclusively to the production of aircraft and related units. The new company, located in Los Angeles, is fabricating a complete line of 4-way and shut-off valves for pressures up to 6000 psi. and up through 1½-inch pipe size. These units for water, oil, gas and pneumatic service may be obtained for manual, solenoid and pressure actuation.

Born Agent to New York

Richard Morton has been appointed eastern representative of Born Engineering Company, Tulsa, engineers and

NEW and *exclusive* HI-LO *Limitorque* 2 Speed *Automatic* Valve Operator

. . . prevents "*Surge*" or "*Hammer*" during closure of Valves, by *automatically controlling speed* of Valve Operator

Another *first* with "Phillie Gear" . . . Another *exclusive* feature available for use with the internationally known *LimiTorque* Automatic Valve Operator . . .

AN ALMOST "MAGIC" DEVICE THAT *PREVENTS:*

- Damage to pipeline valves and station pumps
- Breaks in pipeline caused by "surge"
- Damage to expensive equipment
- Injuries to personnel

A DEVICE THAT *ELIMINATES:*

- Line "surge" or "hammer" during valve closure
- Need for elaborate pressure-relief and storage facilities
- Necessity of by-pass valves because of greatly increased torque during initial valve opening
- Elements of human error, to a great extent, in pipeline operation

The Hi-Lo 2 speed device is *new—different—exclusive*, and when combined with *LimiTorque*, gives *simple, positive, automatic* and *safe* "Remote Control" of Valves.

Above illustration shows gate valve with first nine-tenths of travel closed in 45 seconds, and last one-tenth of travel to close in 120 seconds. However, change from high to low speed can be made at any pre-determined point of gate travel.

Be convinced; write for more complete details.

Philadelphia Gear Works, INC.

ERIE AVE. AND G ST., PHILADELPHIA 34, PA.

NEW YORK • PITTSBURGH • CHICAGO • HOUSTON

IN CANADA: WILLIAM AND J. G. GREEY LIMITED, TORONTO

Industrial Gears and Speed Reducers
LimiTorque Valve Controls

contractors. He will be located in New York where he has been active in petroleum refinery engineering. He was formerly with Hydrocarbon Research, Inc.

Union Carbide Executives

Morse G. Dial has been elected a director, and Kenneth H. Hannan elected his successor as secretary of Union Carbide and Carbon Corporation.

Dial, a graduate of Cornell University, who joined the corporation in 1929 as a member of the sales staff of Carbide and Carbon Chemicals Corporation was successively sales manager and general manager of the Pyrofax Division. In 1937 he became assistant secretary and treasurer, and has since served as secretary and treasurer, and vice president of Union Carbide and Carbon Corporation.

Hannan is a graduate of Yale Law School, and a member of the corporation's legal staff since 1936. He returned to the finance department of Union Carbide in 1946, and has been assistant secretary and treasurer of the corporation, and treasurer of the Electro Metallurgical Division since 1948.

VanFleet Appointed Manager

William VanFleet, recently appointed eastern division manager of The National Supply Company, to succeed Ernest N. Smith, retired, has been associated with the company since 1913. After working at stores in Findlay, Ohio, Tilbury, Ontario, and Butler, Pa., he was appointed store manager in Bolivar, N. Y., in 1929, became a district manager in 1934 and since 1942 has been assistant manager of the eastern division of the company.

Bethlehem Supply Names Two California Managers

Erwin Graves

P. B. Erwin has been appointed manager of production and service for Bethlehem Supply Company of California. He is succeeded as manager of machinery sales by J. C. Graves, Jr. Erwin, in his new position, will manage a newly created department whose function is the servicing of Bethlehem machinery provided through the company's ten field stores and two warehouses to the petroleum industry of California. Bethlehem Pacific Coast Steel Corporation is located in Los Angeles.

Engineering Representative Joins Bethlehem Steel Export

David C. McLaughlin, engineering representative for Bethlehem Supply Company at Dallas, has taken up new duties as oilfield engineering representative for Bethlehem Steel Export Corporation with headquarters in New York City. A 1931 graduate of Penn State College, with a B.S. degree in petroleum engineering, McLaughlin was first employed by independent oil and gas well operators in northern Pennsylvania. During 1933 and 1934 he was an engineer-geologist for the old Venezuela Gulf Oil Corporation in the Oficiana and Santa Rosa districts of eastern Venezuela. Returning to the United States in 1934 he joined the Oil Well Supply Company, and later served as sales engineer until 1939, when he entered the employ of Bethlehem Supply Company at Dallas.

Bethlehem Steel Export Corporation, January 2 became exclusive export distributor for all products of Bethlehem Supply Company of Tulsa, wholly owned subsidiary of Bethlehem Steel Company.

Weston Electrical Engineer Becomes Tagliabue Executive

Employed with Weston Electrical Instrument Corporation, Newark, N. J., since 1924, Anthony H. Lamb has been appointed vice president in charge of operations of the company's affiliate, C. J. Tagliabue Corporation.

Credited with 80 U. S. and foreign patents, Lamb is known the world over as a pioneer in the field of photoelectricity. He first joined the company as an instrument assembler and was successively appointed senior engineer and head of the relay and control division. For his work in the development of special instruments for the armed forces during the war, Lamb received a personal achievement award from the U. S. Navy. When C. J. Tagliabue Corporation was purchased by the company in 1948, he was appointed assistant chief engineer of the parent organization and acting chief engineer of the affiliate.

KINNEY PUMPS

Always Dependable!

Kinney Heliquad Rotary Pumps are famous for performance. One of these HQA Pumps, in petroleum service since 1928, was inspected after 21 years on the job. It was found to be good as new, with no sign of wear at any point. Such a record is not surprising. A survey made on 1685 Kinney Pumps having an average age of 9.2 years, showed an average cost for repairs of only 1.65% of the original cost for each year's service! Materials pumped included all grades of petroleum products from crude oil to asphalt, coke oven by-products and tar. Kinney Heliquad Pumps are always dependable and cost less in the long run.

Write for Bulletin L48—the full story on Kinney Pumps

Pump delivers a continuous, non-pulsating flow. Handles fluids of all viscosities—from gasoline to molasses.
Heavy duty, anti-friction bearings maintain close tolerances for long lasting efficiency.
Steep helical rotors, driven by steel timing gears, pump fast — capacities up to 2100 U. S. G. P. M.

KINNEY MANUFACTURING COMPANY

3596 Washington St., Boston 30, Mass.

NEW YORK • CHICAGO • PHILADELPHIA
CLEVELAND • NEW ORLEANS • HOUSTON
LOS ANGELES • SAN FRANCISCO • SEATTLE

Better Supply of Water Promised by New Process

"An end to water shortages" as well as "accelerated production of basic power resources for industry and government" are announced as the goals of Horizontal Underground Drilling, Inc., and Ground Water, Inc., two firms which recently acquired control of the Ranney horizontal drilling process.

Maurice H. Van Bergh was elected president of both companies and John W. Foster, chairman of the board. Directors include Sylvan Gotshal, Leo Ranney, inventor of the process, and Aaron Schwartz, former director and chief engineer of Celanese Corporation and presently a director and officer of Celanese Corporation of Canada and Mexico.

In seeking a greater bulk of underground water—or oil— the Ranney process exposes a larger area of the sands by tunnelling under the formations and drilling numbers of short wells upward into them. It might also be used to mine coal from above the ground, it was explained.

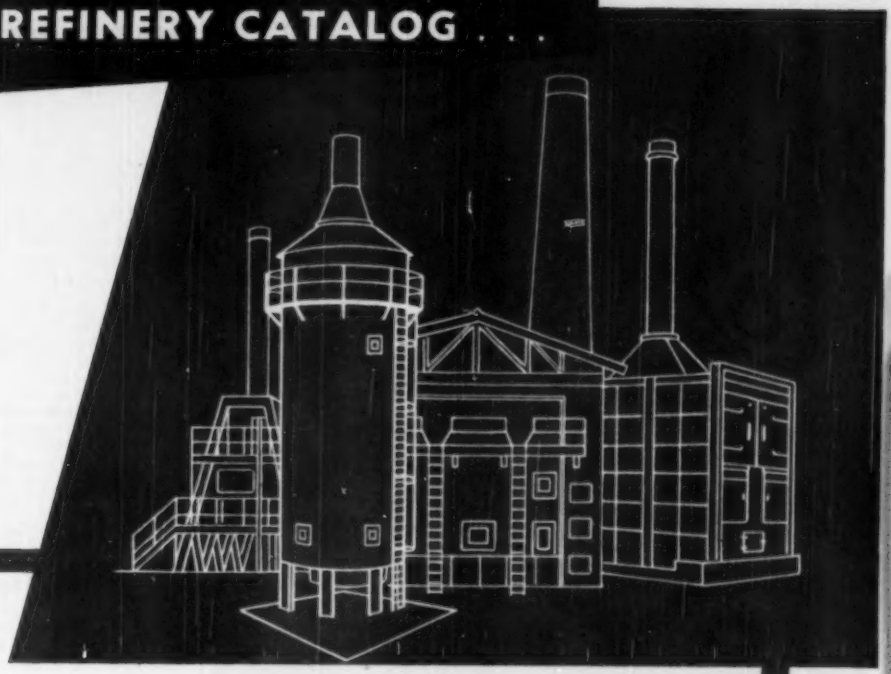
Headquarters are at 70 East 45th Street, New York.

Magnolia Airco Executives

M. G. Wicker and H. T. Wadley have been elected vice presidents of the Magnolia Airco Gas Products Company.

Both were district managers for Air Reduction Sales Company, a Magnolia Airco affiliate, prior to their promotion. Their sales territories, which included portions of the states of Oklahoma, Louisiana, and Arkansas, will now be serviced by the Magnolia Airco organization. Wicker will continue headquarters in Oklahoma City, and Wadley will remain

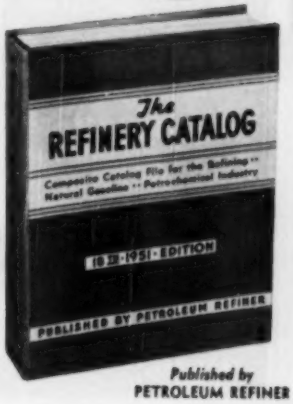
23 HEATER MANUFACTURERS HAVE THEIR CATALOGS FILED IN REFINERY CATALOG . . .



HEATERS are but one of almost 2,000 different items of refinery equipment cataloged in the current Refinery Catalog. No wonder Refinery Catalog is the equipment bible of men who buy and specify equipment the world over. Whatever you buy, whenever you buy, look it up in RC. Three hundred and thirty manufacturers have their catalogs filed between its covers to help make your buying job easier.

The REFINERY CATALOG

THE UNIVERSAL EQUIPMENT GUIDE OF REFINERY BUYERS


The
REFINERY CATALOG
Composite Catalog File for the Refining ·· Natural Gasoline ·· Petrochemical Industry
PUBLISHED BY PETROLEUM REFINER

Published by
PETROLEUM REFINER

in Shreveport, La. Both men have been with the Air Reduction organization for over 20 years.

Union Malleable Exports Handled by Bessemer Steel

Bessemer Steel Corporation, 141 Broadway, New York, has been appointed to manage the export business of Union Malleable Manufacturing Company, Ashland, Ohio, producers of malleable iron pipe fittings, steel pipe nipples and cast copper solder fittings.

Bessemer Steel Corporation has a staff of representatives in foreign markets who will handle all Union Malleable export business of their respective areas. Frank Kafka, Bessemer president, is assisted by M. B. Waterman and Theodore A. Platz.

Dudley K. Bailey of Weston Joins Beedle Sales Staff

Dudley K. Bailey, until recently a member of the sales engineering staff of Weston Electrical Instrument Corporation, has joined the sales staff of Beedle Equipment Company, the Cincinnati district representative for Weston Electrical Instrument Corporation's products.

Except for a three-year war period Bailey had been with Weston since 1937 in production and sales.

Midwest Piping Manager

Phil R. Becker has been appointed sales manager of the welding fittings division of Midwest Piping & Supply Company, Inc. Becker joined the firm's engineering department in 1939 and worked on detailing and designing of fabricated piping. From 1941 to 1945 he was with the welding fittings division, working in engineering and production control and with the government on allocations and priorities. Since 1945, his sales service has been spent in the welding fittings division.

Eagle-Picher Engineer Named To Head Insulation Sales

The resignation of Douglas Via as sales manager of the industrial insulation department, Cleveland, Ohio, and the appointment of Walter D. Myers his successor has been announced by The Eagle-Picher Sales Company. Via will join the King Roofing & Heating Company and Affiliates of Cincinnati, as general manager.

Myers

Myers, with The Eagle-Picher Company for five years formerly was a sales representative for the Pittsburgh area and head of industrial insulation sales in the New York market. Ten years were spent as superintendent of Corhart Manufacturing Company, a unit of Corning Glass Company. Myers studied chemical engineering for four years at Purdue University and electrical engineering one year at the University of Louisville.

Hooker Company Promotes Two in Technical Sales

David M. Coleman and Harris C. Miller have been promoted to Hooker Electro Chemical Company's sales staff. Coleman, who is with the sales development department, will handle technical correspondence for all company chemicals. Miller is assigned to the New York City sales area with headquarters at 60 East 42nd Street.

A graduate chemist of Worcester Polytechnic Institute, Coleman came directly to Hooker Electrochemical Company in 1943 to work in fine chemicals production. He has more recently been associated with the process study group. Miller has been associated with the company since 1941 as process study engineer and in connection with special plant engineering and production assignments.

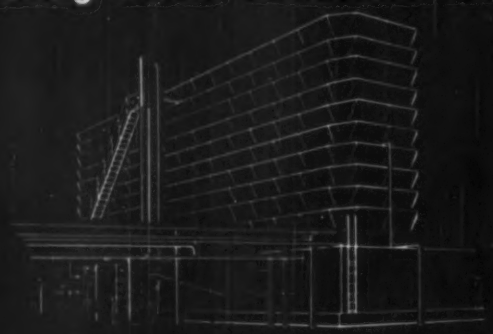
Laclede-Christy Director

A. B. Agnew, vice president in charge of operations of Laclede-Christy Company of St. Louis, Mo., has been elected a director.

New International Division

Mine Safety Appliances Company, Pittsburgh, has established an international division to coordinate the activities of its subsidiaries in Canada, South Africa and Great Britain, and to continue the activities of the present export department. C. M. Donahue will be manager of the new division, in addition to his present duties as manager of the mining division. H. E. Redenbaugh will be assistant manager of the international division.

How to Solve *Your* Cooling Water Problems . . .



No two cooling water problems are ever identical. Variables include the water itself, the cooling equipment and operating requirements as well as atmospheric conditions that change with the seasons and with the hour. Without continuous chemical control the development of scale, or corrosion, or biological fouling will cause inefficient operation of the entire cooling system.

For the solution of even the most unusual cooling water problem BETZ offers a complete consulting engineering service. Over two decades of experience have made Betz water conditioning service scientifically correct, complete . . . economical. Our nationwide staff of engineers will welcome the opportunity of discussing your water problems.

W. H. & L. D. BETZ, Gillingham & Worth Streets, Philadelphia 24, Pa.

BETZ

COOLING WATER CONDITIONING • BOILER WATER CONDITIONING

Rockwell Manufacturing Names Chief Engineer of Division

L. A. Dixon, vice president of Rockwell Manufacturing Company, has announced appointment of E. R. Gilmore as chief engineer of the company's Macnick Division, Tulsa. This division manufactures fluid measurement instruments, chart clocks and parking meters.

Gilmore has had long experience in research and development of equipment for the measurement and control of fluids. After graduating from Rensselaer Polytechnic Institute in 1920 he joined Cities Service Company in Bartlesville, Okla., as a junior engineer and worked on several distribution properties and in various gas fields throughout the midcontinent area. In 1936 he joined the Pittsburgh equitable meter division of Rockwell Manufacturing Company as a project engineer. He was successively plant engineer and chief engineer, supervising the development of gas, gasoline and oil products.

Rockwell Manufacturing Company has an extensive field research program which Gilmore has been directing for the past year. It is gathering data and statistical information on performance of equipment to be manufactured by the Macnick division.

Pettibone Mulliken Buys Johnston & Jennings Firm

Pettibone Mulliken Corporation, a 70-year-old Chicago concern, has purchased The Johnston & Jennings Company of Cleveland, including its Oceco division, handling vent valves, flame arrestors, gages, swing lines and other tank equipment. The company will be known as The Johnston & Jennings Company, division of Pettibone Mulliken Corporation, with new address of 4710 West Division Street, Chicago 51. The entire finished inventory of Oceco products, including all work in process, records and others have been moved to the Pettibone Mulliken Corporation's 30-acre Chicago plant's enlarged engineering and development department, where latest laboratory and testing facilities, and modern manufacturing techniques are available.

George Fox, sales manager, and other key engineering and production personnel have been transferred to Chicago. Sales representation continues virtually unchanged.

Whiton Machine Appointments

The Whiton Machine Company, New London, Conn., has announced that O. D. H. Bentley has joined the company as consulting engineer on steam turbines with Eugene B. Williams in charge of turbine sales for U. S. Navy applications.

Bentley was formerly chief engineer of B. F. Sturtevant Company, Boston. He will be in charge of new designs and developments of Whiton turbines for the U. S. Navy and also for commercial work. Williams, who was vice president in charge of sales for B. F. Sturtevant Company, will concentrate on the requirements of steam turbines for the U. S. Navy.

Riordan Elected Treasurer

Dennis A. Riordan has been elected treasurer of Hooker Electrochemical Company succeeding John F. Bartlett, who was retired in December as treasurer and assistant secretary.

Riordan has been associated with the company since 1924 as accountant, New York office, chief accountant and assistant treasurer.

Duriron Names Two Executives

R. Merton Shields has been appointed secretary of Duriron Company, Inc., Dayton, Ohio. Shields is a mechanical engineer, graduate of Michigan College of Mining and Technology, and former manager of the Dayton district sales. He has been with the company since 1936.

Guy A. Baker, with the company 20 years, has been named vice president in charge of manufacturing. He has been assistant to the president and secretary, and manager of alloy castings sales.

Union Malleable Opens New Warehouse at Fort Worth

Union Malleable Manufacturing Company, Ashland, Ohio, has announced opening of its new Fort Worth warehouse to serve customers in Texas, New Mexico, Arkansas, Louisiana and Oklahoma.

Located at the corner of Kentucky and Presidio Streets, the warehouse is under the direction of Lester Wingard. Sales representatives in the area include Lloyd Jones, Sherman Keevil, Stanley Stach and Pete Wharton.

The U-Brand line of pipe fittings includes malleable pipe fittings, steel pipe nipples and cast copper solder fittings.

3-STEP PLAN
TO SAVE MONEY
ON CLEANING
Like every thrift-minded executive these days, you are determined to cut your production costs wherever possible. That is why Oakite Products, Inc., offers you the following 3-step Oakite money-saving plan to help you carry out your program of economy.
Step No. 1
CLEANING DRUMS, BARRELS: Use any one of three performance-proved Oakite procedures . . . machine-cleaning; tank-cleaning; steam-detergent cleaning. You'll find each will help cut costs. Each will make possible faster cleaning for quicker re-use. The booklet goes into details. Write for your free copy.
Step No. 2
STRIPPING PAINT FROM STORAGE TANKS: Now planning to re-paint storage tank exteriors? To prepare surfaces for anti-corrosion treatment? To clean tank for product changeover? Then your best bet is specialized Oakite cleaning. You'll find facts and figures in booklet. Free on request.
Step No. 3
SALVAGING TOOLS, OTHER EQUIPMENT: Don't scrap used tools, fittings, valves, chains, other things. Chances are Oakite cleaning will make these good as new . . . ready once again to go to work for you. What better way to make a real substantial saving? Write for informative booklet. No obligation, of course.
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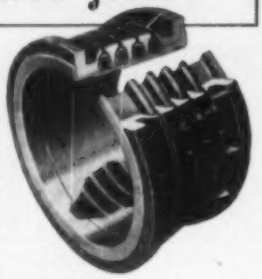
. . . then you want to avoid "trouble-makers". You'll save work with Badger Joints because they respond to thrust quickly — eliminate wear and tear on adjacent equipment. No maintenance on the joints themselves either, thanks to single tube packless construction.



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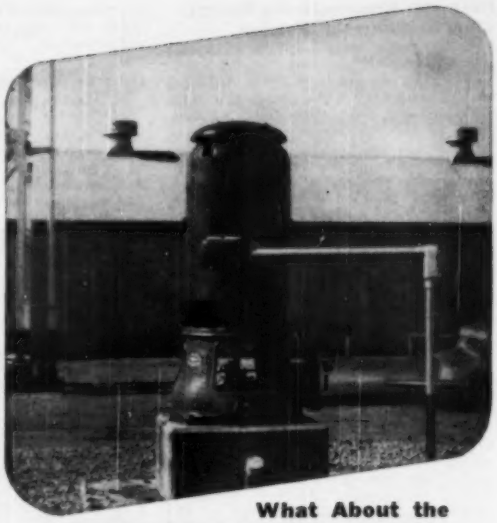

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Kinney Opens New L. A. Office

Kinney Manufacturing Company on March 1 will open its new Los Angeles office at 3942 West Slauson Avenue.

American Brake Shoe Opens New Houston Sales Office

American Brake Shoe Company has opened a new sales office at 2620 Maury Street, Houston, and William C. George who has been appointed southwestern sales engineer will represent Brake Shoe's American manganese steel, electro-alloys and national bearing divisions in the new office. His activities will center in Oklahoma, Texas and Louisiana.

George

George, formerly in the sales department of electro-alloys division, and with Brake Shoe since 1939, was formerly associated with Carnegie Illinois Steel Corporation. A native of Princeton, Ind., he is a chemical engineering graduate of Purdue University.

Tube Turns to Manufacture Welding Fittings in Canada

Tube Turns of Canada, Ltd., which was granted its Dominion charter December 2, is establishing a plant in Chatham, Ontario, for the manufacture of welding fittings. Preparations are being made for installation of machinery and facilities in the two-story, brick plant. Operations will start in about three months.

Tube Turns of Canada, Ltd., is a subsidiary of Tube Turns, Inc., Louisville, Ky.

Graver Extends Distribution In New Sales Representatives

Operating in southern California, Mexico and lower California, Fred. S. Renauld & Company, Los Angeles, will represent Graver Water Conditioning Company, manufacturers of equipment for water conditioning processes. Brookman-Kron Associates will represent the company in sales engineering in the Buffalo, N. Y., territory, and Russell R. MacDonald Company in the Richmond, Va., area.

Graver Water Conditioning Company's main offices are at 216 West 14 Street, New York 11.

Ralph B. Carter Company Names Wheatley to Oklahoma-Kansas

Charles Wheatley Company, 414 South Detroit Avenue, Tulsa, has been named representative for Ralph B. Carter Company in Oklahoma and Kansas. The Wheatley company will handle the latter's entire "Humdinger" line of self-priming centrifugal and diaphragm pumping units—to pipe line companies, pipe line contractors and pipe line supply houses, as well as to the production, refining and marketing divisions of the oil and gas industry.

Petro-Chemical Barium Agent

Petro-Chemical Equipment Company, Inc., has been appointed sales representative in the sales and service on products

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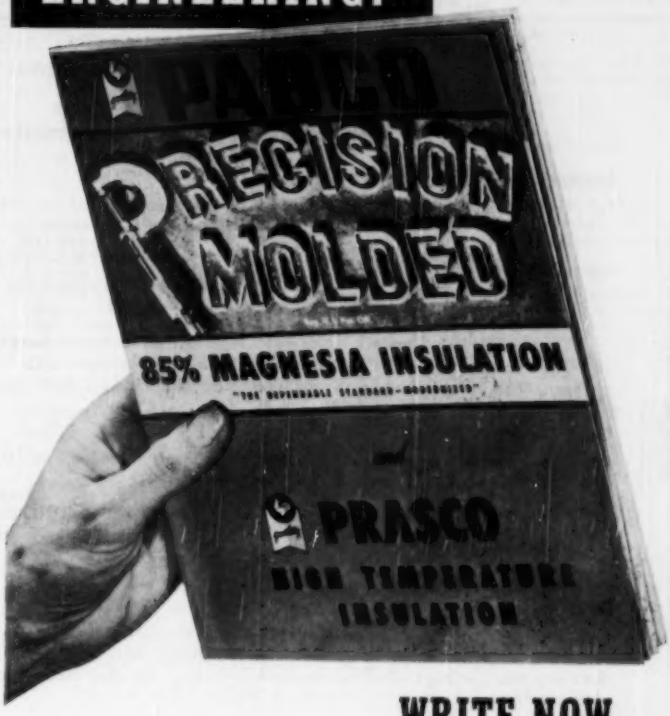

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CHEMICAL COMPOSITION:

(a) The castings shall conform to the following requirements as to chemical composition:

	GRADE "F"
Chromium, per cent	25.0–28.0
Nickel, per cent	10.0–12.0
Manganese, per cent	0.50–1.25
Silicon, per cent	0.25–1.75
Sulphur, maximum per cent	0.05
Phosphorous, maximum per cent	0.05
Carbon	Within limits of Paragraph 4 (c)

(b) The chemical limits for all other added alloying elements, such as molybdenum, titanium and nitrogen, shall be specified by the manufacturer. The material shall conform therewith.

CREEP STRESS AND CERTIFICATE:

(a) The indicated creep rate of the material shall not exceed 1% in 10,000 hours when stressed by a tensile load not less than the following:

TEMP. °F.	STRESS PER SQ. IN. 1% CREEP IN 10,000 HOURS GRADE "F"
1400°	4200#
1500°	3700#
1600°	3200#
1700°	2600#
1800°	1950#

(b) Manufacturer shall submit standard creep data and residual physical properties made on material of his own manufacture and certified by an ACCREDITED LABORATORY. The chemical analysis of the creep test specimens shall be reported, including nitrogen content and any other special alloying elements.

TENSION TEST FOR DUCTILITY AFTER HEATING:

(a) Each heat shall conform to the following requirements as to tensile properties after the specimen has been subjected to a temperature of 1400° F. for 24 hours and furnace cooled to 400° F. Test shall be made at room temperature.

	GRADE "F"
Tensile Strength, min.lb./sq.in.	80,000
Yield Strength, min.lb./sq.in.	35,000
Elongation in 2", min. per cent	9.0

Copy of complete specification will be mailed upon request.

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of Barium Steel and Forge, Inc., manufacturers of quality hammer and press forgings. Petro-Chemical Equipment Company, Inc., is represented by J. C. Riley, Jr., and George E. Shaw, both graduate engineers with experience in the chemical, petroleum and industrial field in the Southwest.

Honeywell Promotes Martenis Manager Sales Engineering

William W. Martenis has been appointed manager of sales engineering of Minneapolis-Honeywell Regulator Company. He will assist in planning specifications, approve new developments and coordinate activity between the sales and engineering departments.

Martenis is a graduate of the University of Minnesota where he received bachelor's and master's degrees in engineering. He joined the company in 1931. After several years in the engineering test department, he was named chief designer and later promoted to chief application engineer.

Honeywell's Sales Staff Is Expanded in Seven Cities

Seven additional men, who will specialize in the sale of its industrial controls, valves and Brown Instruments division pyrometer supplies have been named to the field staff of Minneapolis-Honeywell Regulator Company. Included are Bruno Krause, Pittsburgh; R. A. Schwarz, Minneapolis and St. Paul; T. Sabottke, Hartford, Conn.; W. P. Ryan, East Orange, N. J.; D. Fritch, New York; C. Swanson, Detroit, and L. M. Crowe, Cleveland.

York Corporation Changes In Sales Department Staff

William R. H. Eby, who has been branch manager at Seattle, has been appointed industrial sales manager of York Corporation's Pacific district, headquarters in Los Angeles. Eby has been with York since 1930, following his graduation from the University of Arizona with a B. S. degree in mechanical engineering.

C. Mason Gerhart, formerly assistant to the commercial sales manager will now be in York, Pa., as sales engineer. He joined the company in 1946 upon graduation from the University of Arizona with an M. E. degree.

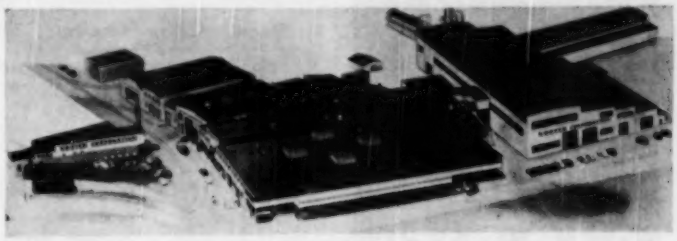
ACF Elects New Director

Robert B. Colgate has been elected a director of the American Car and Foundry Company. A graduate of Yale University, Colgate was formerly vice president of research and development and a member of the executive committee of Colgate-Palmolive-Peet Company. During World War II he was a commander in the U. S. Naval Reserve, serving as chief of the chemical section, production branch of the Office of Procurement and Matériel.

Limbert Representing Dravo

Geo. B. Limbert & Company, Inc., Chicago, has been appointed representative for Dravo Corporation, Pittsburgh, in the sale and installation of fabricated piping. Territory includes Illinois, Wisconsin, Minnesota, Iowa, Northwest Indiana, Western Michigan and St. Louis County, Mo. Limbert is headed by DeWitt C. Showers and John D. Purdy.

Nooter's New Plant, St. Louis



View of Nooter Corporation's new plant at St. Louis. Under the new name, adopted because of expansion in scope of service, there will be no change in management, personnel, policies, or address of the original company which was John Nooter Boiler Works Company.

Oil Well Supply Opens New Iberia Sales Store

Oil Well Supply Company, U. S. Steel subsidiary, has opened a new branch sales store at New Iberia, La. Manager of the new store, which is located at 614 Jane Street, is John D. Boggs, Jr. Boggs joined Oilwell in May, 1947, as a storeman in Houston. Since January, 1948, he has served as store manager at Eunice and Jennings, La.

Spencer Chemical Manager

Spencer Chemical Company has promoted William Schopflin assistant sales manager, Industrial Chemical Sales. He has been with the company since 1946, and was formerly sales supervisor, Industrial Chemical Sales. Headquarters will be in executive and sales offices, Kansas City, Mo.

New Mexico Oxygen Plant

Magnolia Airco Gas Products Company has opened a new oxygen plant in Hobbs, N. M. The new plant which is supervised by William Bowhay, will also serve as an acetylene warehouse point.

Marsh Instrument Manager

R. E. Barnett has been promoted assistant sales manager of Marsh Instrument Company, sales affiliate of Jas. P. Marsh Corporation. With the organization for the past nine years in a sales

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Maybe it all *does* look prety much the same at first glance. But when a firm has been making wire mesh for 70 years man and boy, there's bound to be a little more to it than meets the eye —a little more know-how in engineering and weaving, a little more quality in the product, a little more service and satisfaction to the user.

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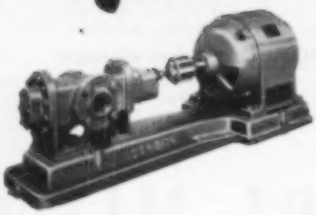
VISCOSITY means nothing to the SIER-BATH SCREW PUMP



THIS pump is recommended for liquids of all viscosities, ranging from fluids such as solvents, to highly viscous substances similar to molasses, grease, Bunker "C" oil, cellulosics, etc.

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capacity, Barnett will work with the company's nation-wide sales organization to promote and maintain maximum coordination with the home office in Skokie, Ill.

Sheffler-Gross Firm Admits Sales Engineer as Partner

G. Kenneth Fisher has been admitted to Sheffler-Gross Company, sales engineering firm, as a general partner. Fisher has been with the company since he joined as a sales engineer in 1940, four years after he was graduated from Drexel Institute of Technology with a degree in mechanical engineering.

Fisher

The company which maintains offices in the Drexel Building, Philadelphia 6, specializes in heating and power plant equipment and temperature control apparatus, including bellows assemblies, shaft seals, automatic radiator control valves, damper regulators and gauges for indicating liquid level in tanks.

Jerguson Gage and Valve Names Ford Vice President

James A. Ford, sales manager of Jerguson Gage & Valve Company, Somerville, Mass., was elected vice president and director at a recent meeting of the board of directors. Ford came to the company as sales manager in 1945.

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Marley Manager Heads Merchandising Sales Group

Robert L. McFadin with the company since 1948, has been named manager of the merchandising sales department of The Marley Company, Inc., and has transferred to the main offices in Kansas City, Kan. For the past year, he had been in charge of merchandising sales in New York, and now will have charge of such sales for the entire organization.

McFadin

McFadin attended Wisconsin University, and after a period in the Air Corps resumed his studies at Michigan College of Mining and Technology, receiving his engineering degree there. He has worked for Carrier Corporation and, W. T. Grant Company, the latter as engineer in charge of air conditioning.

Rockwell Instrument Unit From Pittsburgh to Tulsa

Rockwell Manufacturing Company has moved the main part of its instrument manufacturing facilities from Pittsburgh to its Macnick division in Tulsa, Okla. Products involved are the orifice meter, integrator and related parts. The move is said to be in keeping with the company's policy to have products manufactured as close to the market as possible when other factors relating to manufacturing make it practical to do so.

Other products manufactured by the other 16 subsidiaries and divisions of Rockwell include Pittsburgh equitable meters and regulators for gas, water and oil industries; Nordstrom and Edward valves; Delta, Delta-Homecraft, Crescent and Multiplex wood and metal working power tools; Ohmer taxi meters, cash registers and fare registers; Rockwell Packaging Machines; V & O punch presses; Arcade refrigeration hardware; Hydraulic drives, iron and brass castings.

Laclede-Christy Products Available from Canada

Laclede-Christy Company, St. Louis, has announced that it can now supply refractory users in Oregon, Washington, Idaho, Alaska and certain export territories various qualities of fireclay brick, special hand-molded shapes, and arch and wall tile from Abbotsford, B. C., Canada. This service is a result of a long-term resale agreement with Clayburn Company Limited, at Vancouver, B. C.

Construction of the Abbotsford plant, a modern fire brick plant, is being completed. Fireclay available to this plant ranges from P.C.E. 30 to 34.

Houghton Laboratories Enters The Manufacturing Field

Houghton Laboratories, Inc. of Olean, N. Y., formerly an industrial consultant on protective coatings and corrosion control, has entered the manufacturing field and is making a series of new anti-corrosive metal primers and surface coatings, as well as a new plastic material called Hysol 6000. The Hysol coatings are used for protecting steel

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Houghton has built a pilot plant and research facilities in which Hysol products will be tested under all possible conditions, according to Russell Houghton, president.

New Allis-Chalmers Shop

The Smith-Milligan Electric Company, 624 East Third Street, Tulsa, has been named a certified service shop for Allis-Chalmers motors and controls in Oklahoma, east of and including Kay, Pawnee, Creek, Okfuskee, Hughes, Coal, Atoka and Bryan counties.

C. G. Smith is president, and J. C. Milligan, secretary and treasurer of the Tulsa company, which was organized in 1927.

Oakite Representatives Hold Meeting

OAKITE REGIONAL MEETING—Highlighting Oakite Products, Inc.'s recent technical sales meeting in New York, were reports by company research chemists and service engineers on latest trends in cleaning and related procedures designed to assist industry in combating rising production costs. Also reported were new materials for the company during 1950.

Shown here are field service representatives from the company's Canadian, New England, New York, and Philadelphia sales divisions. Similar regional conferences during the past two months have included representatives from Chicago, Cleveland, midwestern, Milwaukee, St. Louis, and southern divisions, and from the north Pacific, south Pacific and southwestern territories.

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Catalytic Chemistry

By HENRY W. LOHSE

Consulting Chemist, Fellow of the Royal Society of Arts, London; Canadian Institute of Chemistry; American Chemical Society; American Assn. for Advancement of Science.

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This book aims at a factual presentation of the underlying principles of catalytic phenomena and the application of catalytic reactions in industrial processes.

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Casper, Wyo., Company Named Orbit Valve Representative

LeRoy Mitchell, a manufacturer's representative, heading The Great Western Company of Casper, Wyo., has been appointed to represent Orbit Valve Company products in the Rocky Mountain and Canadian oil fields.

Mitchell

Maintaining an office and warehouse in Casper, the company serves the industry with production and refining equipment manufactured by W. C. Norris Manufacturing Company, Johnson Block Company, and Orbitt Valve Company, all of Tulsa.

Arthur Schwarz Appointed Nooter Sales Executive

Nooter Corporation of St. Louis has announced the appointment of Arthur Schwarz as vice president in charge of sales. Schwarz has been connected with the firm since 1935. Robert J. Ryan is executive vice president; S. C. Tracy vice president and treasurer; and H. A. Frith, vice president and superintendent.

Sales Personnel Transfer

General Refractories Company, Philadelphia, has made transfers in sales personnel as follows: William C. Noble, from the estimating department to the Philadelphia district sales office; Karl E. Spaeth Jr. from the New York warehouse to the Pittsburgh district sales office; and Richard A. Stephens from the New York warehouse to the Philadelphia district sales office.

Company Office Moved

Seventeen Charlton Avenue, West Hamilton, Ontario, is the new location of R. D. Travers Company, Canadian representative for Cambridge Wire Cloth Company. Former headquarters were at South Hamilton, Ontario.

Selas Chicago Office Moved

The Chicago office of Selas Corporation of America, heat processing engineers, is now located at 3857 W. Washington Boulevard, Chicago 24, Ill.

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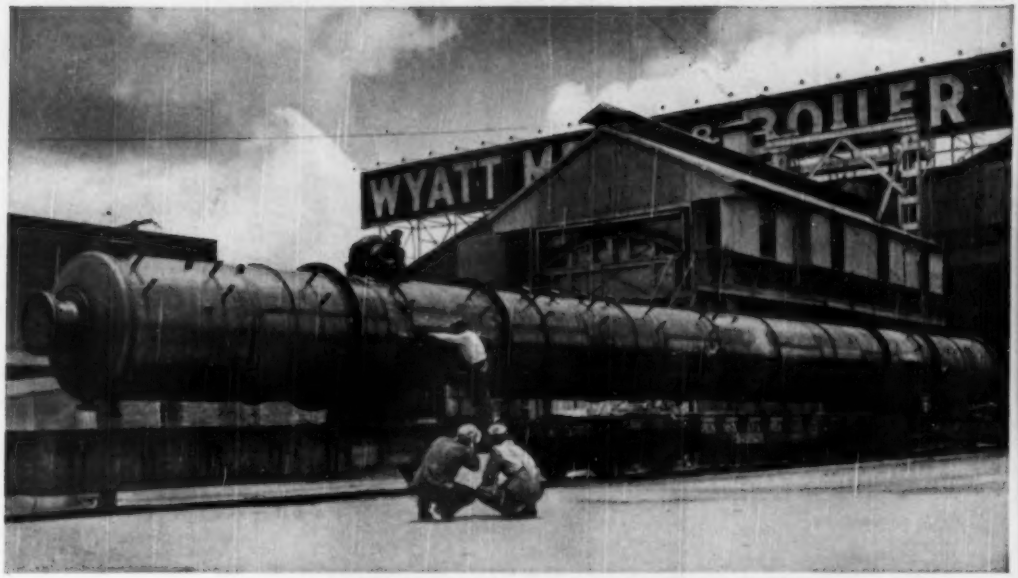

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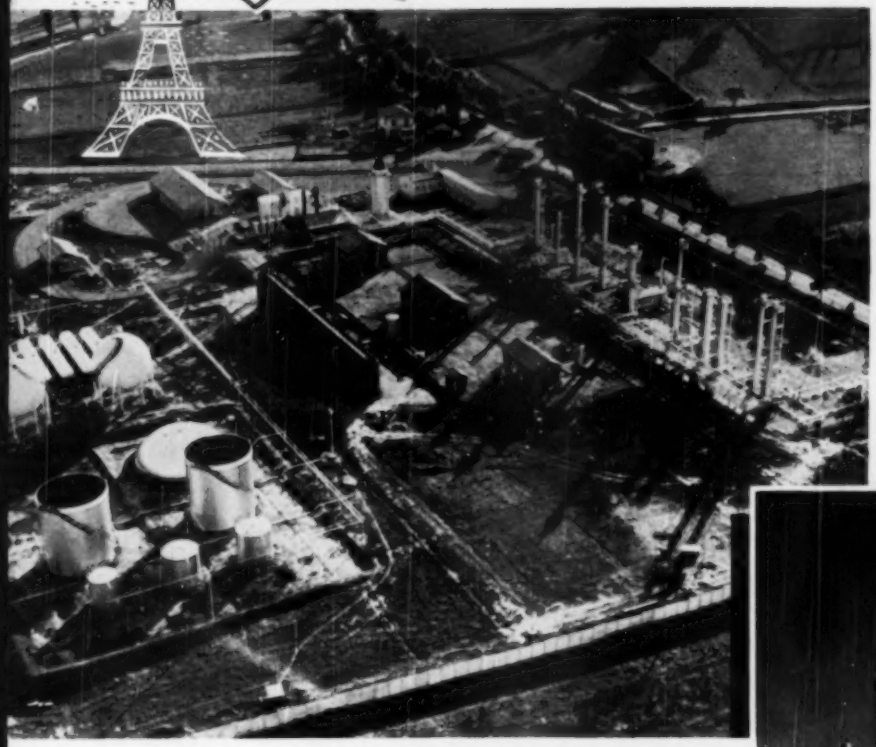

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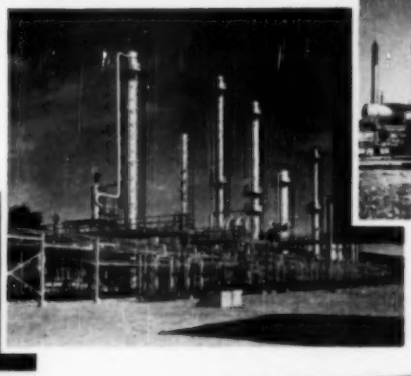

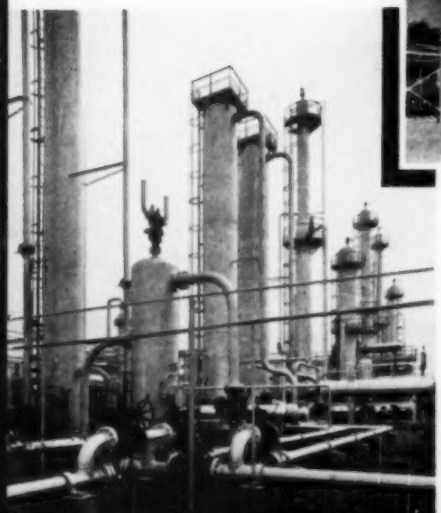

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